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EDITORIAL

CIGARETTE TOBACCO IN CEYLON

DURING the past two years or so the Department of Agriculture has been experimenting with the growing and curing of several varieties of tobacco with a view to finding a type which would be suitable for local conditions of soil and climate, and which, by special curing, would produce a light type of cigarette tobacco catering for a wider market than the ordinary chewing tobacco grown by local cultivators. These experiments have indicated so far that a Virginian type of cigarette tobacco known as Harrison's Special seems to be the most suitable type, but other types are still under trial. Some notes embodying the results of the actual cultivation and harvesting of this tobacco were published in *The Tropical Agriculturist*, LXXXV, No. 1, July 1935, pp. 10-20, and further information, mainly about flue-curing, appears in the current number.

In the July number full details were given on the cultivation of tobacco and much of this information applies to any type of tobacco. It was emphasised, however, that cigarette tobacco can be profitably grown only on the lighter types of soil with a suitably drained sub-soil. Another essential factor in the production of cigarette leaf of the right colour is to arrange the planting of the crop so as to be able to harvest in dry weather, otherwise much of the leaf will inevitably have a bad colour or may be spoilt by disease, such as "frog-eye". For this reason,

the *maha* season may prove to be more suitable for cigarette tobacco. Experiments with a *yala* crop are also under trial. These are points which will have to be seriously considered by cultivators of cigarette tobacco if they are to produce a profitable crop.

It should be clearly understood that it is not every crop of Harrison's Special which is necessarily suitable for flue-curing. However much care the grower may take in raising the crop he must inevitably depend on climatic conditions at the critical stages of the crop. Unseasonable weather at almost any stage of the crop may produce disastrous results or may depreciate the quality of the leaf to such an extent that it is not worth flue-curing for the best cigarette tobacco and can only be air-cured for other purposes.

In the current number detailed instructions are given as to the size and number of flue-barns required for the acreage under cultivation in any given locality, and as to the construction of a barn and its furnace. The problem of devising a type of flue-curing barn and furnace suitable for local conditions seems to have been solved satisfactorily. The barn is of the mud and wattle type which can be built easily and cheaply by the cultivator, and the furnace can be cast locally at a reasonable cost for use in this type of barn. The three stages undergone by the leaf during flue-curing, namely, yellowing, fixing the colour and drying, are explained at some length. The temperatures given there are those found suitable under the conditions prevailing at Wariyapola and are intended to serve only as a guide to cultivators, who must learn to use their own judgment in adapting these temperatures to suit their individual barns and the particular season during which curing is being done. Flue-curing, however, is a somewhat specialised process and cultivators will for a time doubtless need considerable assistance from those officers of the Department who have had practical experience in the cultivation and curing of cigarette tobacco. The results obtained so far have indicated that, given the right kind of soil and with careful attention to cultivation, harvesting and flue-curing, a good type of cigarette tobacco can be grown in Ceylon with the prospects of a profitable return owing to the duty on imported leaf.

THE CULTIVATION AND CURING OF CIGARETTE TOBACCO—*(Contd.)*

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FLUE-BARN

Special rooms are necessary for the curing of cigarette tobacco. These rooms are known as flue-barns because of the use of the flue pipes for heating the room.

Barns should be near the homestead in a tobacco field because it allows for the convenient supervision of the work. A supply of water should be handy. The building should be so placed that the prevailing winds do not blow through the furnaces.

SIZE OF BARN

The size of a flue-barn to be erected on a holding will depend on the area of tobacco usually grown each year in the scheme of rotation to be adopted. As the furnace used for flue-barns is of cast iron and the cost of casting depends on the weight to be cast the minimum size of furnace that could be economically cast will be 3 feet deep by $1\frac{1}{2}$ feet wide by $2\frac{1}{2}$ feet high. A furnace of these dimensions should serve to heat a barn 16 feet by 12 feet by 24 feet high. It is a mistake to have a barn too tall because the curing does not take place uniformly in all the tiers. A barn of the dimensions given above should serve to cure leaf from about $3\frac{1}{2}$ acres of tobacco at one time. Where the area is larger a larger barn is needed and for such a barn the furnace should be proportionately larger. The largest size of flue-barn which can be efficiently heated by a single furnace is 16 feet square by 24 feet high and the furnace should be 2 feet wide by 3 feet deep by $2\frac{1}{2}$ feet high. A barn of these dimensions could

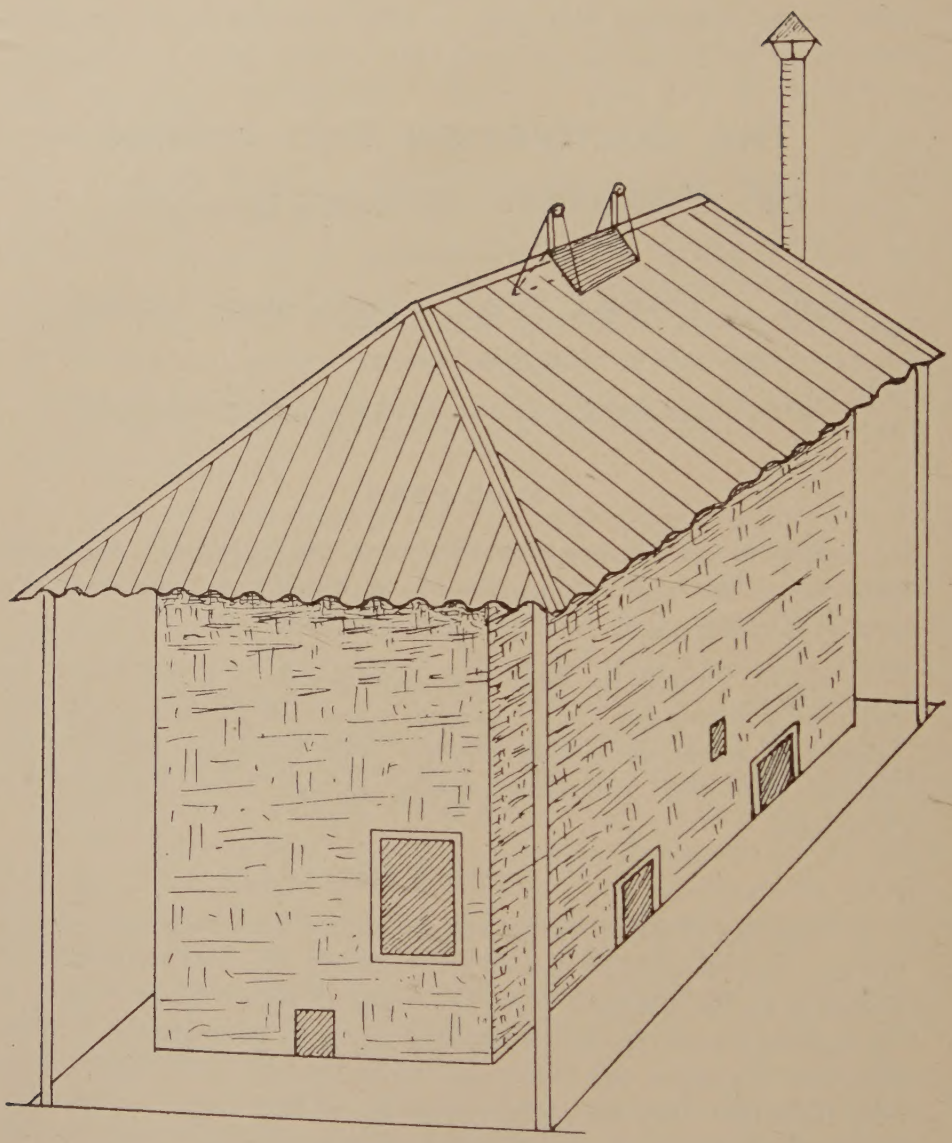

Plate I

A general view of a Flue-Barn. The door of the furnace is shewn at the base of the front wall and the door to the barn about three feet from the ground level. Note also the two ventilators on the side wall and the adjustable ridge ventilator on the roof.

hold at one time leaf from about $4\frac{1}{2}$ acres. When larger areas of tobacco are grown it is more economical to build and manage a single barn of larger dimensions than to have several smaller barns. Large barns should, however, be provided with two furnaces. The largest size of barn which can be heated by two furnaces is 20 feet by 24 feet by 24 feet high. Each furnace should be 4 feet deep by $1\frac{1}{2}$ feet wide by $2\frac{1}{2}$ feet high. A barn of these dimensions can hold at one time leaf from eight acres.

CONSTRUCTION OF BARN

A building of wattle and daub walls and roof of corrugated sheets can be used for a flue-barn. A verandah all round the room is desirable and the roof should slope on all four sides so that rain may be kept off the walls of the barn. The thickness of the wall will depend on the diameter of the King posts which should not be less than nine inches. The mudding should be carried right up against the corrugated sheets of the roof, the idea being to have an airtight chamber, the movement of the air within being controlled by opening the ventilators described below.

A frame for a door 6 feet high by 3 feet wide should be built into the front wall of the barn on a side so that the threshold is about $3\frac{1}{2}$ feet from the ground level. Each of the side walls is provided with two frameworks for ventilators placed at equal distances from the front and back walls. Each ventilator is about 30 inches long by 2 feet high and is placed at ground level. The ventilators can either be hinged on to or slide along the framework. A ventilator which has a Λ shape in section is also fitted on the ridge of the roof so that it can be raised or lowered at will. A glass window 18 in. by 9 in. is also built into any one of the four walls at a height of about 4 feet from the ground so that the reading of the thermometer and hygrometer can be taken out without opening the door.

Each barn should be provided with tier-poles for hanging the leaf for curing. A frame is built up by burying into the ground four stout poles each about 6 inches in diameter and reaching to the roof at the four corners of the room. Poles of smaller diameter but of the same height are erected vertically so that the room is thereby divided into coupes each 4 feet

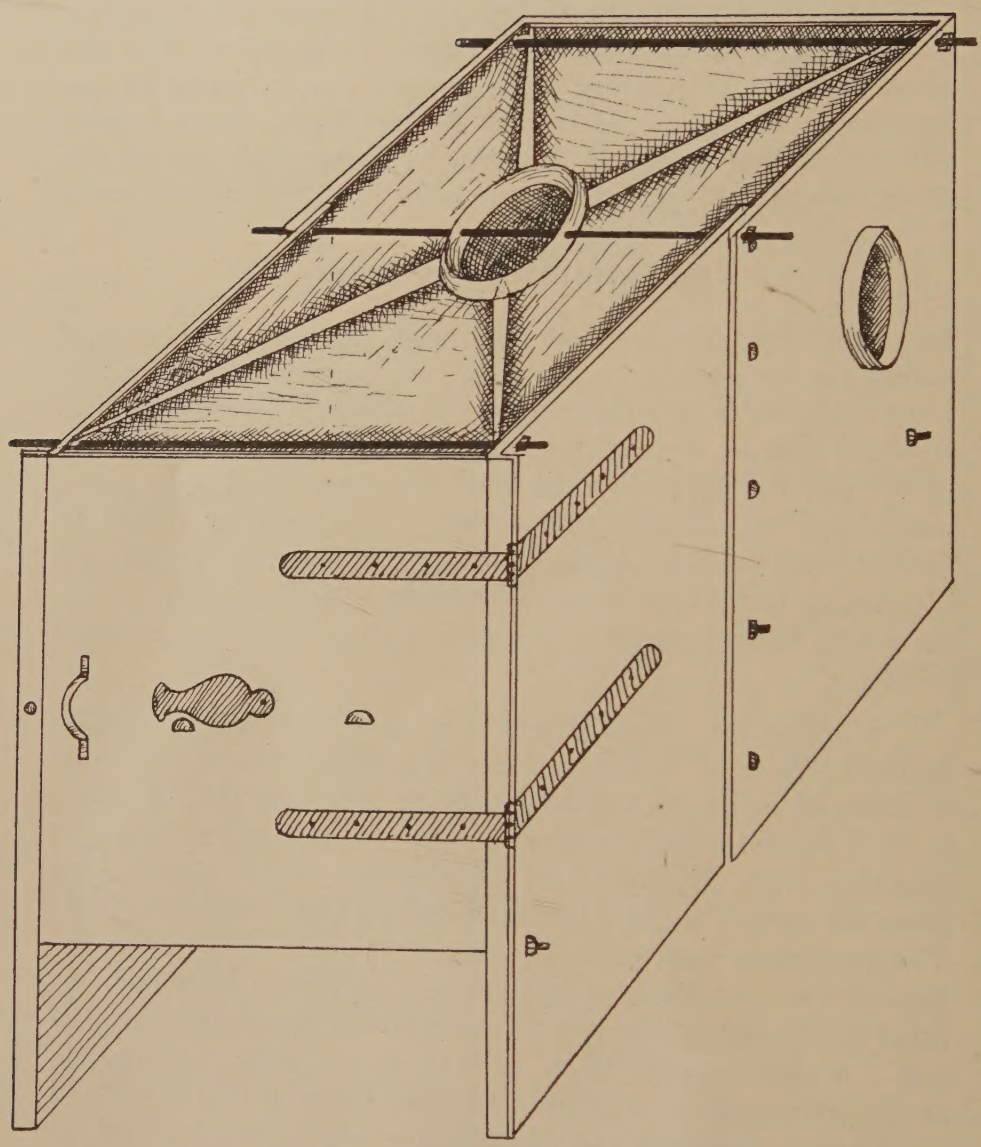

Plate II

A general view of a tobacco furnace. Note the roof reinforced against buckling and the three tier-rods above the roof holding the vertical side plates in position. The circular vent about ten inches in diameter is shown at the rear end of the side plate.

square. These vertical posts are joined together by horizontal ones so that the lower tier is about 7 feet from ground level and each successive tier is about 2 feet above the next lower one. On the framework thus formed are hung the sticks to which the tobacco leaves are strung. Each stick is 4 feet 6 inches long.

FURNACE

(Plate II)

Each furnace should have walls at least half an inch thick. The side walls may be cast in two pieces with either lap or butt-joints bolted together. At the further end of the side wall a circular vent about 10 inches in diameter with a flange 5 inches deep is provided. The flue pipes slide over this flange. The roof of the furnace may be cast in one piece and should be supported on lugs cast on the inside of the side walls of the furnace. Owing to its length the roof should be reinforced against buckling by ridges radiating to the four corners from a central circular flange, the whole being cast in one. The door which is provided with a peep-hole and sliding cover should be hinged to one side of the furnace. The whole when assembled is held together by six tier-rods with their ends threaded so that nuts can be screwed on as tightly as required to hold the side plates in a vertical position. Three tier-rods are fitted just above the roof, one at each end and one at the middle, while three others are similarly placed about nine inches from the base of the furnace. The furnace should be assembled on a level platform at the middle of the front wall of the barn so that its door when closed is flush with the outer surface of the front wall. Each furnace is provided with fourteen fire-bars each $\frac{3}{4}$ inch thick and of the same length as the furnace. The fore end of each fire-bar rests on a cast-iron bearer bar which is supported on lugs cast in the inside of the side walls. The rear end of the furnace is built up with bricks held together with fire clay. The space below the fire-bar serves as the ash-pit and this may be kept closed by bricks loosely assembled, so that they may be removed when the ash is to be cleaned out. A metal frame of flat iron rod 1 inch wide is built into the front wall nine inches from the edges of the furnace. To this frame is hinged shutters of iron sheet which open outwards and serve to regulate the rise of temperature in the barn. A second frame is constructed at the rear end of the furnace. These two frames serve to support sheets of galvanised iron which enclose the furnace on three sides forming a baffle to

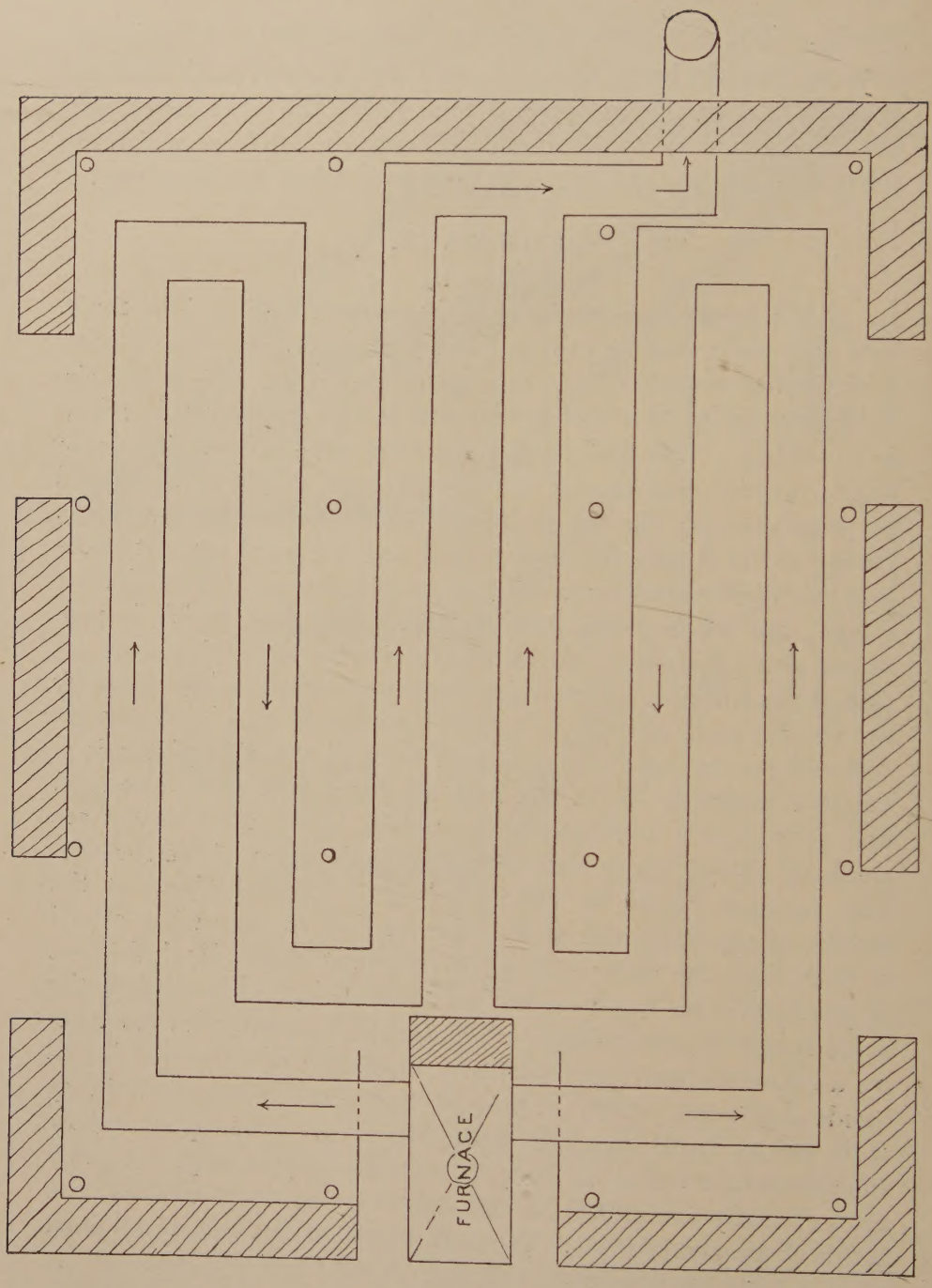

Plate III

A ground plan of a Flue-Barn. The walls are shewn hatched in, the breaks indicating where the ground ventilators are placed. The direction of the heat is shewn by arrows within the flue pipes. It will be noticed that the rear end of the furnace is not of cast iron but bricked in.

keep the direct heat of the furnace from the leaves cured and also serve as an outer chamber within which the heat can be regulated by the shutters referred to.

FLUE PIPES

The flue pipes which could be made of 22 gauge sheet-iron should have a diameter of at least 10 inches. The portion which fits into the flanges of the furnace should be carefully constructed so that a fire-proof joint is secured. The pipes should be arranged as shown in Plate III so that the room is uniformly heated. The fire stack leading the smoke from the flue pipes should be at least 28 feet high, so that a good draught is created.

CURING

Curing consists in the manipulation of the temperature and humidity of the barn when filled with leaf so that the yellowish-green colour of the leaf when harvested is gradually changed into a canary yellow colour and the moisture content of the leaf is considerably reduced. In curing, the composition of the leaf is subjected to a series of chemical changes.

No rule of thumb can be followed in flue-curing tobacco, for what is correct under one set of conditions may not be so under others. Soil, climate, cultural operations and degree of ripeness are factors which influence the duration of the several curing processes. The processes described below hold good only for conditions obtaining at Wariyapola. The duration of the processes for other localities is a matter for experiment.

There are three stages in the curing of tobacco for cigarette purposes.

a. Yellowing.

b. Fixing the colour.

c. Drying the leaf; both web and midrib.

Yellowing.—The barn is filled evenly, taking care that no large spaces occur between leaves or sticks. Should the quantity of leaf be insufficient to fill the barn completely the sticks should be evenly distributed over a fewer number of tiers. A thermometer and a hygrometer are hung just below the last tier of leaves somewhere away from the furnace, preferably in the middle of the room, so that readings can be conveniently taken

through the pane in the window provided. A small fire is started in the furnace and the temperature kept at 90°F.* The ventilators and the door are kept tightly shut during the yellowing stage so that as high a moisture content as possible is maintained in the room. If the leaf is at the right stage of ripeness and the weather conditions normal the moisture given out from the leaf should be sufficient to maintain the required humidity, which should never be allowed to fall below 85 per cent. during the yellowing stage. Should the humidity drop below this through any cause, artificial moisture should be introduced into the barn by placing wet bags over the flues or pouring water over the floor. This should, however, be avoided if possible specially at the later stages of yellowing because it leads to sponging of the leaf which greatly takes away from the value of the cured leaf.

As the temperature in the shade during the curing periods is about 82° it is necessary to raise the temperature to 90° before yellowing can be started in the flue-barn. Even if no artificial heat is used, the temperature inside the barn, when filled with leaf and with the door and ventilators closed, rises to about 90°. Yellowing can be induced and completed by this rise of temperature alone, but this takes about three days and the barn will not be ready for curing the next harvest which normally comes on about a week later.

The temperature is maintained at 90° till the edges and tips of the leaves show signs of yellowing, when the temperature is raised to 95° and kept at that till about 50 per cent. of the leaf surface is yellowed, when the temperature is again raised to 97° and held there until 75 per cent. of the leaf surface is yellowed when the fixing stage is begun. In a barn loaded with leaf of uniform ripeness there should be no difficulty in deciding when the fixing stage should be begun. There is, however, always difficulty because no two persons have the same standard for judging ripeness by colour. In case the yellowing of the leaf does not take place uniformly, it should be carried on until about 60 per cent. of the leaves are yellowed, and this should take place within 18 to 24 hours.

Fixing the Colour.—The last stage in the yellowing of the leaf is also the first stage in the fixing of the colour in the leaf. When about 75 per cent. of the leaf surface has yellowed and,

* Farenheit temperatures are given throughout this paper.

in a barn filled with leaves of uneven ripeness, when about 60 per cent of the leaves have reached this stage, the fixing is begun by raising the temperature to 100° and raising the ventilator over the ridge of the roof half the length of its travel. The raising of the ventilator reduces the humidity as the moisture would otherwise settle on the surface of the yellowed leaf causing it to turn a reddish-brown colour and this is known as "spongeing".

The temperature is maintained at 100° till the whole surface of the leaf is yellowed with only traces of green along the veins and mid-ribs, and the temperature is then raised to 102½° and the four bottom ventilators opened to a quarter of their travel. This stage is a matter for experience, and until one has gained enough experience it is wise to raise the temperature to 102½° while there is still a pronounced greenish tinge about the yellow. After the temperature has been held at 102½° for one hour the temperature is raised by 2½° every hour till 110° is reached and this will be the end of the fixing stage. At 105° the ridge ventilator is fully opened and the bottom ventilators half opened while at 107½° all ventilators are fully opened. The opening of the ventilators serves to regulate the moisture content of the barn and the appearance of "spongeing" or an indication on the hygrometer of a high moisture content in the barn should be a signal for opening the ventilators wider than is described above. Fixing the colour takes about 8 to 10 hours.

Drying the Leaf.—The drying of the leaf begins at 110° with all the ventilators fully open. As the most critical period in curing is when temperature of the leaf is between 110° and 120° care should be taken never to let the temperature drop, as is likely to happen at night or in rainy weather. The temperature is raised at the rate of 2½° per hour from 110° to 125°. In order to accustom the leaf to the high temperature keep it at 125° for three hours and then raise it to 130° and keep it at that till the web of the leaf is two-thirds dry. It usually takes about 4 to 6 hours before the temperature can be raised from 130°. The temperature is then raised at the rate of 5° per hour to 140° and kept at that till the web of the leaf is quite dry. The raising of the temperature from 110° to 140° and the complete drying of the web of the leaf take from 22 to 24 hours.

After the web of the leaf has been completely dried raise the temperature to 165° at the rate of 5° every two hours. This temperature is maintained until the midribs are quite dry. At the end of this stage the midribs should snap with a crack when bent between the fingers. The fires are then allowed to die down and the door and ventilators left open to let the cured leaf become flaccid enough for handling. At 155° the bottom ventilators may be partly closed to economise fuel. Under no circumstances should the temperature of the barn be allowed to go above 165° because the soft silkiness and bright colour of the leaf will be destroyed and the leaf will also become brittle.

SHINGLING

The leaf when pliable enough for handling is removed from the barn on the sticks and "shingled". In shingling the sticks are arranged one on top of the other so that the next upper stick overlaps the leaves of the lower by one-third of their length. Shingling should always be done on a clean dry floor. The shingled sticks form a heap about 4½ feet square and the heap is covered over with some mats or clean gunnies. In favourable weather the leaves can be detached from the sticks the next day. If rains prevail the heap is left till dry weather comes on.

GRADING

Before grading, the cured leaf should be in the right condition for handling, *i.e.*, it should be slightly flaccid so that it will not break in handling. It should neither be wet nor too soft because it will then turn mouldy fast. A bundle of leaves when held by the butts, shaken out and held with the tips of the leaves upwards should, if in the right condition for handling, remain erect or only slightly drooping.

Grading is best done on the farm as it gives the grower a chance of seeing his tobacco at its worst and of knowing what return he may expect from the several grades.

Colour is the base for grading cigarette tobacco. Sub-grades are formed from leaves of the same colour but of different quality.

The following are usually recognised grades of cigarette-tobacco:

Grade i. Bright canary yellow coloured.

ii. Bright orange coloured of less clearness than Grade i. In this grade will be placed blotched or slightly sponged leaves.

iii. A fair amount of colour but insufficient for Grade ii.

iv. A greenish tinge free from blotching or spongeing. After six or eight weeks these leaves would have lost enough green to be included in Grade i or ii.

v. All leaves which cannot be included in the above 4 or the 6th Grade. This will include all sponged and dark leaves.

vi. This grade should not occur if harvesting and curing have been correctly done. All dark-brown and green leaves are included in this grade.

BULKING

Leaves of the different grades are bulked separately. About 25 leaves are bundled into a "hand" and tied together by a leaf of the same grade. The hands are heaped on platforms to a height of about 6 feet. The heaps are covered over with hessian or mats. A dark room is best for storing bulked tobacco. The heaps should be broken up once in 10 to 14 days and rebulked so that the upper hands will go to the bottom of the heap.

TRANSPORT

Prior to transport each grade is packed separately with the aid of a bailing press into bales of sizes suitable for handling. The hands must not be pressed too tight.

After completing harvest uproot and burn the stalk and trash within one month as a precaution against the spread of pests and diseases.

COSTS

The following cost per acre are approximate:

	R. c.
Nursery	5·00
Preparatory tillage	7·50
Levelling and draining land ...	10·00
Lining and pegging	1·50
Fertilising	15·00
Cost of fertilisers	50·00
Transplanting and supplying vacancies	10·00
Shading	5·00
Watering	25·00
Weeding	7·50
Removing shade	1·00
Intercultivating	10·00
Pests and diseases	4·00
Topping	1·00
Suckering	3·00
Harvesting	15·00
Stringing	5·00
Loading Barn	1·50
Curing	5·00
Shingling & bulking	1·50
Grading	20·00
Rebulking	5·00
Uprooting tobacco stumps ...	3·00
Depreciation on barn on a six-year life	100·00
Total cost.	311·50

YIELD

One acre of Harrison's Special tobacco if grown on ideal conditions of soil and climate should yield about 4 cwt. of first grade leaf.

PESTS AND DISEASES

The greatest handicap to the realisation of appreciable yields in tobacco cultivation is the occurrence of pests and diseases. The chief pests and diseases observed on tobacco are dealt with in this paper. The control measures and spray formulae are those recommended by Entomologist and Mycologist of the Department of Agriculture.

Attention should be given to plant sanitation by collecting and burning all dead and diseased plants or parts of plants which should never be left lying about in the field.

PESTS

Stem-borer (*Phthorimaea heliopa*).—This pest usually starts in the nursery where the moths lay eggs on either side of young leaves. When the eggs hatch in 4 to 6 days the larvae — tiny caterpillars—start boring inside the leaf. For the first day or two these larvae feed as leaf-miners and then proceed to the midribs of leaves and finally bore into the stems in about a week's time. The stems infested by the borer swell out and the growth of the plant is impeded, the leaves forming a rosette appearance.

Control Measures.—1. Cover the seed beds with crepe cloth. 2. Spray the nursery in the early stages regularly with an arsenical mixture. 3. Plants should be given a good start by avoiding overcrowding in the nurseries and growth stimulated by fertilising the seed beds. Should the pest be noticed in seedlings after they have been transplanted an incision is made in the swollen part of the stem with a sharp knife, the caterpillars removed and killed and the wound in the seedling filled in with a little clay. Such plants should in dry weather be watered liberally.*

Leaf Caterpillar (Prodenia litura).—This is a prolific breeder, one moth laying 300-400 eggs in one mass. The caterpillars cluster together and eat the under surface of the leaves which are thus reduced to skeletons.

These and other leaf-eating caterpillars are controlled in the young stages by spraying nursery beds either with an arsenical spray or with a solution of 1 lb. of soft soap in 8 gallons of water, or by hand picking. Overcrowding in nursery beds should be avoided.

DISEASES

Damping off.—This is caused in seed beds by *Rhizoctonia solani* and is easily avoided by having seed beds sufficiently raised to ensure proper drainage. Should damping off occur as is seen by the dying off of seedlings in patches, remove all the affected plants and water this patch freely with a solution of Jeye's Fluid — 1 oz. to 1 gallon of water. The usual watering should be stopped and the shade over the seed beds removed to hasten the drying of the seed bed.

Frog-eye.—This disease is caused by *Cercospora nicotianae* which attacks the plant at any stage of its growth and causes

* For fuller information on this pest see *The Tropical Agriculturist*, LXXXIII, No. 1, July 1934, pp. 64-66. Also obtainable in leaflet form.

irregular spotting over the leaf surface. It is not possible to completely eliminate this disease and the only hope is to reduce the incidence by adopting the following measures:

1. Soaking seeds in a solution of silver nitrate strength 1 to 1,000. The seeds are placed in a muslin bag and well shaken in this solution for 15 minutes, washed in several changes of water and dried out in the shade before sowing.

2. Spraying seed beds once a week with Bordeaux mixture 2-2-40.

3. Removal of diseased leaves as soon as they are noticed in the field. This cannot however be done to excess as the growth of the crop will be impeded.

Bacterial Wilt.—This disease is well known to tobacco growers in this Province and is the cause of much loss. The base of stem and main roots become partially rotted and discoloured. The leaves and the green shoots wither progressively and the whole plant puts on a wilted appearance. The stem shows dark brown streaks externally, while in section a brown colouring of the tissues is seen spreading upwards and extending from the pith to the cortex.

Plants with broken or wounded roots are most liable to infection by the bacteria which live in the soil. In transplanting care should be taken to avoid breaking roots or damaging the seedlings. In cases of severe attacks avoid growing tobacco at least five years on the same land. Crop rotation with the elimination of solanaceous crops (*e.g.*, tomato, chillies, brinjal) should be adopted.

Eelworm.—Plants attacked by this nematode show signs of wilting and the leaves yellow prematurely. When such plants are pulled out the presence of the eelworm is indicated by tuberculous swellings on the roots which in severe cases resemble a warted potato. A bare fallow in which the land is regularly ploughed up and kept free from all weeds followed by a cereal crop is the only form of control. All attacked plants should be uprooted, heaped up and burnt *in situ* to avoid conveying the the disease to other plants which are free. Legumes such as cowpea are very susceptible to eelworm attack, but there are immune varieties.

Mosaic is characterised by the mottling of the leaves which show dark veins when held against the light. There are several forms of this disease which is caused by an ultra-filterable virus. Collecting and destroying all plants attacked by this disease is the only form of control. Avoid handling healthy plants after touching diseased ones.

STUDIES ON CEYLON SOILS

VI.—SOME FOREST SOILS OF THE WET LOW-COUNTRY

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IN this paper the profiles of typical forest soils of the south-west low-country of Ceylon are dealt with. They were studied in connection with an investigation in co-operation with Mr. H. C. King, retired Divisional Working Plans Forest Officer, on the relationship, if any, between the growth and distribution of forest species, particularly Hora *(Dipterocarpus zeylanicus)*, and soil factors. Seven soil profiles of forests extending over an area from Matara in the Southern Province to Mirigama in the Western Province were examined. The rainfall in the area varies from 80 inches at the former location to 130 inches at the latter. The variation in elevation is much less marked, the range being between 100 and 700 feet. Temperature conditions are more or less the same over the area, being about the average low-country temperature, viz: 80°F. These data will therefore be omitted in the profile descriptions. The data for the elevations, rainfall, botanical species, etc. of the respective forests were kindly supplied by Mr. King. The geological formation underlying the soils is Charnockite, a series of igneous rocks belonging to the Archean system, and their mode of formation, is mainly residual. There is, however, some indication that the soils in one or two of the locations are derived from the Pleistocene plateau gravels.

The soil profiles do not appear to show any characteristic B horizon, the demarcation between the A & C horizons being often quite distinct. These forest soils are typical red loams, of a definitely lateritic nature verging in certain cases to laterite.

The soils vary in texture from sandy to clay loams, the C horizons being generally of heavier texture than the A horizons. In certain of the profiles the stone and gravel contents of the horizons are very high. Where the soil constituents do not form a compact mass but occur as partly decomposed boulders embedded in a loamy matrix, as in the Beraliya reserve, root development is deep and extensive and forest growth good. Where, however, as is the case at Yakkatuwa, this high stone and gravel content is made up chiefly of lateritic gravel forming a compact mass, root development is prevented and growth appears to be comparatively poor. It would seem probable that the consistency of the soil horizons and the disposition of the gravel and stone in them determine the degree of root penetrability and forest growth.

Chemically, the soils are all acid to markedly acid in reaction, the acidity diminishing slightly with depth. The carbon contents are fairly high in the A horizons of all but one profile, the amounts varying from 0·98 to 2·96 per cent. The corresponding organic matter contents are 1·70 to 5·10 per cent. These percentages are not as high as might be expected of forest soils. The nitrogen contents of the A horizons are, with a few exceptions, very fair. The C horizons are generally very deficient in both carbon and nitrogen. The carbon/nitrogen ratios generally show a decrease from about 15 in the A horizons to about 10·5 in the C horizons. The total exchangeable base contents are very low in all the horizons. The proportion of replaceable calcium varies appreciably in the different profiles, being about 50 per cent. of the total in the A horizons and lower in the C horizons. Replaceable potassium is very low in all the profiles. The total lime and phosphoric acid contents are also very low.

The observations on the profiles are given below and the analytical data presented in tables I, II and III at the end of this paper for purposes of comparison.

1. MASMULLEKELLE PROPOSED RESERVE

Location	...	About 8 miles north of Matara.
Elevation	...	100 to 350 feet.
Rainfall	...	80 in.
Geological origin	...	Igneous; Charnockite.
Mode of formation	...	Residual.
Drainage	...	Free.

Topographic position	...	Undulating, steep in parts.
Vegetation	...	Mainly Hora; often found in pure stands. Other genera are Calophyllum, Dillenia, Artocarpus, Mangifera, Garcinia, Myristica, Carallia and Chaetocarpus.

PROFILE

A. 0-14 in. Yellowish grey sandy loam, blackish brown humus layer in top 3 in.; well-disintegrated; fair quantities of ironstone and quartz gravel; coarse granular to small clod; friable and porous; good root development; horizon boundary distinct.

C. 14-48 in. Yellowish red clay loam with concretions and small boulders up to about 2 in. diameter; irregular clod; compact; hard when dry but fairly friable; fair root growth.

ANALYTICAL DATA AND DISCUSSION

An examination of table I will indicate that the soils are loams, the C horizon being much heavier in texture than the A layer. The organic matter and nitrogen contents are fairly high in the A layer and low in the C horizon The soils are distinctly acid in reaction, the acidity diminishing with depth. The lime requirement of the surface layer is fairly high, but not as high as its acidity might indicate. The total lime and phosphoric acid contents are low.

2. KEKANADURA RESERVE

Location	...	About 8 miles north-east of Matara.
Elevation	...	50 to 150 feet.
Rainfall	...	75 in.
Geological origin	...	Probably igneous; possibly Pleistocene plateau deposits.
Mode of formation	...	Residual or possibly transported.
Drainage	...	Good.
Topographic position	...	Level to undulating.
Vegetation	...	Hora is the dominant species. It is believed that it does not attain a girth of over 7 feet. Associated genera are Garcinia, Vitex, Calophyllum, Dillenia, Myristica, Wormia, etc.

PROFILE

A. 0-10 in. Brownish grey sandy loam, darker in first 3 in. very few concretions; coarse granular to small clod; friable and porous; good root development; very distinct horizon boundary.

C. 10-36 in. Brownish yellow loam; very high proportion of stones, gravel and ferruginous concretions forming a hard, impenetrable layer; few boulders up to 6 in. diameter; conglomerate and nodular; very compact; root growth very poor.

ANALYTICAL DATA AND DISCUSSION

Table I will show that the soils of both A & C horizons are sandy loams. The latter however contains over 61 per cent. of stones and gravel and forms a layer which is penetrable by roots only with difficulty. The sticky point moisture is fairly low for soils of this texture. The organic matter and nitrogen contents are low in both horizons, the former being particularly low in the A horizon. The soils are acid in reaction, the acidity diminishing with depth. The soils are poor in replaceable base contents. Calcium forms about 50 per cent. of the bases. The poor growth of *Hora* is very likely due to the pan-like C layer; which may be the 'gravel' stratum of the plateau deposits.

3. YAKKATUWA RESERVE

Location	...	Near Elpitiya.
Elevation	...	100 feet.
Rainfall	...	140 in.
Geological origin	...	Probably igneous; possibly plateau deposits.
Mode of formation	...	Residual or possibly transported.
Drainage	...	Good.
Topographic position	...	Gently undulating with intersecting paddyfields.
Vegetation	...	Genera: Chaetocarpus, Canarium, Aporosa, Eugenia, Dillenia, Myristica. Forest much less luxuriant. Girth of all species lower than that of average forest.

PROFILE

A. 0-12 in. Grey brown, well-disintegrated loam; ironstone concretions and quartz gravel in fair abundance; coarse granular to small clod; fairly compact; root growth fair; horizon boundary distinct.

C. 12-48 in. Yellowish red gravelly loam mottled red; ironstone nodules, partly disintegrated, forming firmly compact layer; nodular; very hard; root development very poor.

ANALYTICAL DATA

The A & C horizons of this profile are medium loams, the C horizon being only slightly heavier in texture than the surface layer. It however contains nearly 55 per cent. of stones and gravel which form a compact mass, restricting root development. The carbon and hence organic matter contents of the A horizon are the highest of the profiles examined. The C horizon also contains fair proportions of this constituent. The A horizon is rich in nitrogen while the C horizon is poor in this constituent. The soils are acid in reaction. Base exchange contents are poor. The analysis of the clay fraction of the A horizon shows an alumina content of 48·2 per cent., an iron oxide content of 14·0 per cent. and a silica content of 34·4 per cent. The silica/alumina molecular ratio is 1·21, indicating that this soil is definitely a laterite. This fact coupled with the existence of the pan-like C horizon would account for the poor growth of forest species on this area.

4. BERALIYA PROPOSED RESERVE

Location	...	Near Elpitiya.
Elevation	...	100-150 feet.
Rainfall	...	140 in.
Geological origin	...	Igneous, Charnockite.
Mode of formation	...	Residual.
Drainage	...	Good.
Topographic position	...	Very steep; sample from midway down slope.
Vegetation	...	A great variety of forest species. Most important genera are Hora, Palaquium, Doona, Hopea, Shorea, Eugenia, Calophyllum, Vitex, Chaetocarpus, Myristica, Mangifera, Messua, Garcinia, Wormia, Dillenia, Bassia, Canarium, etc. The maximum height and girth of all species is considerable.

PROFILE

A. 0-13 in. Grey brown sandy loam darker at surface; well disintegrated; few concretions; coarse granular to small clod; compact but permeable; very good root growth; fairly distinct horizon boundary.

C. 13-48 in. Yellow sandy loam with faint reddish tinge at lower depths; small boulders, partially decomposed, up to 6 in. diameter embedded in matrix; irregular clod; compact; fairly hard but friable; root growth fair.

ANALYTICAL DATA AND DISCUSSION

The analyses reveal that the A. & C layers are sandy loams, but the latter contains a small proportion of undecomposed and partially decomposed boulders. This makes for good soil drainage. The carbon and organic matter contents of the A horizon are high and the nitrogen content very fair. The soils are more or less uniformly acid in reaction. The replaceable bases are low, and so are the total lime and phosphoric acid contents. The analysis of the clay fractions of the A & C horizons shows them to be similar in composition with alumina contents of about 45 per cent., iron oxide 14 per cent. and silica 36 per cent. The silica/alumina ratios vary between 1·32 and 1·4, but for practical purposes may be considered to be about the same. The soils may then be classed as laterites, the degree of laterisation being slightly greater in the lower depths. In spite of the reputed poverty of soils of this nature, this particular soil area carries an excellent forest vegetation. The soil is of a light texture, well-drained, and contains a good reserve of potential plant food in the form of decomposing boulders. The rainfall of the area is high, viz: 140 in., and so also is the temperature. These factors considered together would probably account for the high degree of laterisation and the luxuriant forest vegetation as well.

5. MIRIGAMA RESERVE

Location	...	About 1½ miles east of Mirigama Rest House.
Elevation	...	200 feet.
Rainfall	...	About 110 in.
Geological origin	...	Igneous.
Mode of formation	...	Residual.
Drainage	...	Good.

Topographic position	...	Undulating; forest intersected by paddyfields.
Vegetation	...	Almost pure Hora; some Artocarpus nobilis, Vitex and Chaetocarpus.

PROFILE

A. 0-9 in. Yellowish brown loam, darker in first 3 in; ironstone nodules and gravel in abundance; nodular to coarse granular; friable, porous; root growth good; horizon boundary fairly distinct.

C1. 9-22 in. Yellowish red clay loam; fairly high proportion of reddish-yellow nodules and ironstone concretions; nodular to clod; compact, firm; root growth fair; horizon boundary fairly distinct.

C2. 22 in. 4 ft. Salmon red clay loam; reddish, well-disintegrated nodules; irregular clod; compact; firm; roots present.

ANALYTICAL DATA AND DISCUSSION

Table II will show that the soils vary in texture from medium loams to clay loams, being heavier with increasing depth. High proportions of stones and gravel are noted in the A & C1 horizons, but the C2 horizon is different in this respect. The carbon and organic matter contents are fair in the A & C1 horizons, but low in the C2 horizon. The A horizon contains a fair supply of nitrogen, but the C1 and C2 horizons are poor in this constituent. The soils are acid in reaction. The total replaceable contents are very low, calcium constituting about 75 per cent. in the A & C horizons. The analysis of the clay fraction shows that the A layer is lateritic in type and the C1 layer approximating the laterite type. The soils are typical red and yellow lateritic loams. Forest growth is fair in this area.

6. MITIRIGALA RESERVE

Location	...	North of Jambulande Estate on the Kelani Ganga.
Elevation	...	100-500 feet.
Rainfall	...	150 in.
Geological origin	...	Igneous.
Mode of formation	...	Residual.
Drainage	...	Good.

Topographic position	..	Undulating; fairly steep in parts; sample from the lower end of a gentle slope.
Vegetation	..	Mainly Hora; other species are Vitex altissima and Artocarpus nobilis.

PROFILE

A. 0-8 in. Yellowish grey sandy loam, with a 2 in. dark humus layer; fair quantities of gravel and semi-decomposed ironstone nodules; coarse granular to nodular; friable and porous; good root growth; horizon boundary fairly distinct.

C1. 8-24 in. Yellowish medium loam with a fairly large proportion of ironstone concretions and nodules; nodular to small clod; fairly compact; root growth fair; horizon boundary indistinct.

C2. 24-48 in. Yellowish red medium loam with a high proportion of partially decomposed ironstone concretions; amorphous when wet; compact, soft; roots scarce.

ANALYTICAL DATA AND DISCUSSION

The A horizon is a sandy loam, while the C1 & C2 horizons are heavier in texture, being medium loams. The former contains about 24 per cent. stones and gravel, and the two latter about 51 per cent. of these constituents. The carbon and nitrogen contents of the A horizon are high, those of the C1 & C2 horizons being low, but fair when compared with those of the corresponding horizons of other profiles. The soils are acid in reaction. Base exchange contents are low.

7. INDIKADA PROPOSED RESERVE

Location	...	3 miles south-east of Waga.
Elevation	...	200-500 ft.
Rainfall	...	150 in.
Geological origin	...	Igneous, Charnockite.
Mode of formation	...	Residual.
Drainage	...	Good.
Topographic position	...	Undulating to steep; sample from mid-way down a slope.
Vegetation	...	Hora; Eugenia species, Mangifera, Litsea, Terminalia, Palaquium Garcinia, Messua, Shorea, Hopea, Doona, Isonandra, etc.

PROFILE

A. 0-18 in. Brown sandy loam with a small proportion of ferruginous nodules and quartz gravel; coarse granular; friable and porous; root development good; horizon boundary fairly distinct.

C. 18-48 in Yellowish red sandy loam with fairly well decomposed ironstone concretions and few large boulders; nodular to small irregular clod; fairly compact but porous; fairly hard but friable; roots down to 30 in.

ANALYTICAL DATA AND DISCUSSION

The A & C horizons are sandy loams. Both contain fair proportions of gravel and concretionary material, but this is higher in the C horizon. Organic matter and nitrogen contents are good in the A horizon and fair in the C layer. The soils are acid, the acidity as usual diminishing with depth. Exchangeable base contents are very low. Calcium forms a high proportion of the bases. The soil is suitable for a variety of forest species.

CONCLUSION

The profile characteristics and analytical data of the seven forest areas studied would indicate that Hora and a number of other useful forest species would grow on lateritic to laterite soils of acid reaction and texture varying from sandy to clay loams, provided that rainfall, temperature and elevation conditions are suitable. The actual analytical composition of the soils does not vary appreciably. The degree and rate of growth appear however to be conditioned by the consistency and the disposition of the stone and gravel constituents in the B and C horizons. In the absence of data regarding the relative sizes and rates of growth of forest species in the areas studied, this conclusion can only be regarded as tentative. The value of a study of the profile characteristics, apart from the analytical examination of the soils of any area it is proposed to afforest or re-afforest will however be apparent. It is therefore suggested that before any extensive forestry scheme be adopted, an exploratory soil profile survey of the area be made. Pits dug to a depth of 4 to 6 feet would be sufficient for the purpose in most cases.

TABLE I

Mechanical Analysis

	Masmullekelle		Kekanadura		Yakkatuwa		Beraliya	
	A %	C %	A %	C %	A %	C %	A %	C %
Stones and gravel	21·3	44·9	4·6	60·6	17·2	54·4	3·1	17·7
Coarse sand	48·7	33·2	49·8	45·6	56·0	48·9	59·8	53·0
Fine sand	18·9	11·7	25·0	28·3	17·4	16·6	14·9	18·8
Silt	10·0	6·6	4·9	2·7	3·3	4·3	4·0	5·7
Clay	18·2	43·9	18·7	19·4	20·6	27·6	19·3	19·7
Loss by solution	2·2	2·1	0·5	2·5	0·5	0·5	0·1	0·1
Moisture	2·0	2·5	1·1	1·5	2·2	2·1	1·9	2·7
Sticky point moisture	31·5	48·0	23·5	28·1	35·4	38·4	34·9	39·7
Texture index number	17·5	40·2	17·3	18·0	21·8	25·4	17·9	18·5
Soil type	Sandy loam	Clay loam	Sandy loam	Sandy loam	Loam	Loam	Sandy loam	Sandy loam

Chemical Analysis

Loss on ignition	9·38	10·04	5·55	6·46	12·16	11·05	7·85	9·29
Organic matter	3·38	0·81	1·69	0·84	5·10	1·41	4·71	1·17
Combined water	6·00	9·23	3·86	5·62	7·06	9·64	3·14	8·12
Carbon	1·96	0·47	0·98	0·49	2·96	0·82	2·73	0·68
Nitrogen	0·137	0·043	0·099	0·046	0·182	0·076	0·152	0·066
Carbon/nitrogen ratio	14·4	10·9	9·9	10·4	16·2	10·7	17·9	10·4
Lime requirement	0·151	—	0·221	—	0·125	—	0·157	—
Reaction	5·0	5·8	5·5	6·3	5·4	6·1	5·1	5·4
Total lime	—	—	—	—	0·093	—	0·080	0·100
,, phosphoric acid	—	—	—	—	0·040	—	0·058	0·050
Total exchangeable bases (m.e. per 100 gm. soil)	1·39	0·70	1·00	0·88	1·29	0·27	1·05	0·46
Exchangeable calcium	0·63	0·31	0·58	0·33	0·69	0·14	0·52	0·17
,, potassium	0·12	0·04	0·05	0·04	0·06	0·02	0·07	0·04

TABLE II

FOREST SOILS

Mechanical Analysis

	Mirigama Reserve			Mitirigala Reserve		Weke	Indikada Proposed Reserve Waga	
	A %	C1 %	C2 %	A %	C1 %	C2 %	A %	C %
Stones and gravel	51·1	42·0	4·6	23·8	50·6	51·1	15·4	30·5
Coarse sand	42·4	35·0	26·9	52·2	48·7	44·6	51·4	62·0
Fine sand	18·4	13·7	15·8	25·2	15·2	8·6	19·4	13·5
Silt	6·0	6·7	11·3	3·6	7·7	14·9	6·0	3·1
Clay	31·3	42·0	42·0	15·9	24·7	27·3	19·8	18·0
Loss by solution	0·1	0·2	0·8	0·7	0·0	0·5	0·4	0·1
Moisture	1·8	2·4	3·2	2·4	3·7	4·1	3·0	3·3
Sticky point moisture	27·7	43·3	48·6	32·4	39·9	42·9	39·9	39·7
Texture index number	28·9	38·5	40·0	14·8	23·0	25·9	18·6	16·6
Soil type	Loam	Clay loam	Clay loam	Sandy loam	Loam	Loam	Sandy loam	Sandy loam

Chemical Analysis

Loss on ignition	6·94	9·37	11·60	9·40	10·27	11·61	13·59	13·33
Organic matter	2·30	1·23	0·70	2·88	1·71	0·90	3·73	1·26
Combined water	4·64	8·14	10·90	6·52	8·56	10·71	9·86	12·07
Carbon	1·33	0·72	0·41	1·67	0·99	0·52	2·16	0·73
Nitrogen	0·09	0·06	0·04	0·14	0·09	0·05	0·14	0·05
Carbon/nitrogen ratio	14·2	12·8	10·2	12·4	11·5	10·4	15·0	13·5
Lime requirement	0·169	0·197	0·201	0·110	—	—	0·145	—
Reaction	5·7	6·0	6·1	5·5	6·1	6·2	5·6	6·0
Total lime	0·080	0·061	0·067	—	—	—	—	—
,, phosphoric acid	0·056	0·053	0·046	—	—	—	—	—
Total exchangeable bases (m.e. per 100 gm. soil)	0·78	0·23	0·16	0·33	0·24	0·24	0·51	0·15
Exchangeable calcium	0·60	0·17	0·10	0·73	0·20	0·22	0·41	0·12

TABLE III

Clay Analysis

	Yakkatuwa	Beraliya		Mirigama	
	A %	A %	C %	A %	C1 %
Loss on ignition	29·14	34·03	22·61	20·16	17·87
Silica (SiO_2)	34·36	37·12	35·12	41·50	41·02
Sesquioxides (R_2O_3)	62·22	59·98	58·88	57·06	58·24
Alumina (Al_2O_3)	48·18	44·62	44·97	43·69	47·51
Iron oxides (Fe_2O_3)	14·04	15·36	13·91	13·37	13·38
SiO_2/Al_2O_3 (Molecular)	1·21	1·40	1·32	1·61	1·46
SiO_2/R_2O_3 ,,	1·02	1·16	1·11	1·35	1·24
Soil type	Laterite	Lateritic to Laterite	Laterite	Lateritic	Lateritic to Laterite

CONTROL METHODS USED AGAINST LOCUSTS AND GRASSHOPPERS*

OWING to the widespread plague of grasshoppers in South Australia during 1933—34, it has been suggested to me that a short survey of the usual control measures adopted against grasshoppers and locusts in various countries would be helpful to farmers and others.

The species causing the present plague is known as the "wandering grasshopper" (*Chortoicetes terminifera*). The infestation extends over South Australia, portions of the northern districts of Victoria, and western districts of New South Wales. More than one species may be involved in this wide-spread outbreak. The outbreaks occur at infrequent intervals of several years. The grasshoppers occur in swarms which vary considerably in size. Compared with the locusts of the old world, the swarms are smaller and their range of migration is more restricted, so that organisation for a control campaign can be made on a more local basis.

Investigations on the ecology of the species in South Australia are being made by the Department of Entomology of the Waite Institute, in co-operation with the State Department of Agriculture. The present article gives a short general account of the chief measures which are adopted in various countries in order to reduce losses due to outbreaks of grasshoppers and locusts; many of them are applicable to the conditions existing in South Australia.

Grasshoppers and locusts belong to the same family of insects. With the former, many species live as solitary individuals, although actually they may be present in large numbers scattered over pasture areas; other species are gregarious in habits and move about in swarms. The habits of these gregarious migrating species closely resemble those of true locusts. In general however, locust swarms are larger and their range of migration is much more extensive.

The life-history of migrating grasshoppers and locusts is simple. The winged females lay their eggs in batches in the ground, in suitable situations, to a depth of about 2 inches. From these eggs wingless hoppers hatch out; they gradually increase in size and eventually become winged males and females. The wingless hoppers and winged forms migrate in swarms, which latter vary considerably in size. The winged swarms congregate on suitable areas in order to lay eggs; these areas are known as "egg-beds", and vary in extent from a few square yards to several acres according to the size of the swarms.

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* By J. Davidson, D.S c., Waite Agricultural Research Institute, University of Adelaide in *Journal of Agriculture of S. Australia*, Vol. 38, December 1934.

The characteristic feature of these insects is their periodic occurrence in plague numbers. In 1921, B.P. Uvarov advanced a theory to explain the reason for these periodic outbreaks; it is known as the "phase theory". According to the "phase theory" a gregarious species may be endemic in particular regions in a non-gregarious or solitary phase. Under certain environmental conditions not yet clearly understood, gregarious individuals develop in these permanent or endemic areas; these individuals multiply and form into swarms which migrate into surrounding areas. These secondary areas are only infested for temporary periods. The extent and intensity of the migration appear to be greatly influenced by weather factors. The phase theory fits well with the behaviour of certain species of locusts.

The exact locations of the permanent or endemic areas of the "wandering grasshopper" in South Australia are not known. They appear to be situated in the dry northern areas of the State, close to the line of the 10 in. annual isohyet. The general direction of migration appears to be to the south. In any case, observations made during the present invasion and those recorded during previous outbreaks show that the occurrence of the insects in numbers in the agricultural areas of the State is only temporary.

It is evident that a study of the ecology of the species of grasshoppers involved in the present plague in Australia is necessary. It is also important that research should be carried out on the causes underlying their occurrence in plague numbers.

1. *Organisation of Control Measures.*—When a mass outbreak of grasshoppers is indicated, it is essential that control measures should be organised on a communal basis if satisfactory control is to be obtained. One important aspect of such an organisation should be the survey of infested areas so as to demarcate situations where eggs have been deposited by flying swarms. A skeleton organisation should be maintained in those agricultural areas liable to infestation, so that early control measures can be taken when an invasion is threatened. Under South Australian conditions the district council appears to be the best unit for a control organisation. It is important that occupiers of land should mark and report areas on their property where the swarms of winged insects have laid eggs. If these "egg-beds" are defined, preparations can be made for dealing with the hoppers hatching out from them. Extensive "egg-beds" may occur on unoccupied land, surveyed roads, or State property; these should be dealt with by local councils or State organisations.

The aim in any control campaign should be the destruction of the swarms of wingless hoppers. It is generally recognised that control becomes increasingly difficult when the insects attain the winged stage. Any common-sense, practical methods may be employed in order to destroy swarms. In an organised State-wide campaign, however, certain methods are more practical than others. Of these, spraying with poison sprays or the distribution of poison bait are methods which are widely adopted. The cost of materials and appliances used in these campaigns may be borne by the Government or by district authorities; the necessary labour can generally be arranged by owners of the land or by district councils.

The amount of money which may be reasonably expended on control measures will depend on the value of the crops in the area threatened by invasion. It is evident that labour may be a heavy item of expenditure unless free co-operation is developed in the districts concerned.

2. *Survey of Control Measures Generally Employed.*—Various control methods are widely practised in many countries; certain of them are suitable for use in organised campaigns, others may be employed by smaller groups of workers.

(a) *Destruction of Eggs in "Egg-beds".*—The insects lay their eggs in batches in the ground to a dept hof about 2 inches; the "egg-beds" may be a few square yards to an acre or more in extent. Where practicable, shallow ploughing or harrowing over these areas will expose the eggs to their natural enemies, such as birds, etc., and also to the influence of weather. With some species, in certain countries, the egg-pods are collected and destroyed.

(b) *Destruction of Hoppers.*—1. Mechanical methods, such as destroying the hoppers by the use of rollers, chain or brush harrows, or other implements, are adopted. Their use is restricted to suitable situations and the efficiency of the method is unreliable.

2. Hopper-catching machines are sometimes used and various types have been designed. While they may be useful in local flat situations, their application is restricted and a high degree of control is not obtained.

3. The distribution of dry material over an area where a swarm of hoppers is present is commonly practised; the hoppers tend to shelter in the material at night and the latter can be fired at appropriate time. The limitations of the method are obvious. Flame-throwers of various patterns have been used, a common form being of the knapsack sprayer type; kerosene and fuel oil may be used as fuel. The method is convenient for small swarms of hoppers; owing to fuel costs it has only a restricted application.

4. The method of digging trenches to intercept swarms of advancing hoppers is widely used in certain countries. It is particularly appropriate against those species in which the hoppers advance steadily and do not readily change their direction; the hoppers may be destroyed in large numbers by this method. Following on the method evolved originally in Cyprus, barriers or screens made with suitable material are used in order to direct swarms of hoppers into pits or trenches. Sheets of smooth galvanized iron or zinc about 18 inches wide have proved effective for this purpose. Barriers may be used to protect a crop from an advancing swarm of hoppers; the latter may be destroyed as they bank up against the barrier, or they may be directed into trenches. The use of the method will depend upon local conditions. Labour costs may be high where frequent changes of the position of the barriers are necessary, owing to the irregular movements of the swarm of hoppers. In suitable situations deep plough furrows will retard the advance of a swarm of hoppers into a crop.

5. Liquid contact sprays for killing young hoppers are frequently used; they are not very effective against older hoppers. Owing to the

strength of the spray required, the method is costly, and contact insecticides, such as kerosene emulsions, are harmful to vegetation. Kerosene-soap emulsion, mineral oils, and carbolic-soap emulsions may be used for spraying newly-emerged hoppers on the "egg-beds".

6. The use of arsenical compounds as stomach poisons in the form of sprays and baits have been widely developed in many countries. Spraying has a limited application in areas where dry farming is practised; it may be used to advantage where water is readily available and the occupier of the land has adequate equipment. It is particularly useful where the herbage growth is vigorous, since baits are not suitable in such situations.

Paris green and sodium arsenite are chiefly used as the poisonous ingredients in these sprays. Molasses added to the spray enhances its attractiveness, but its presence is not essential. The following poison spray has been shown to be effective in Australia:

Arsenite of soda	1 lb.
Molasses	2 lb.
Water	16 galls.

The spray should be applied on a strip of vegetation about 30 ft., wide in front of the advancing swarm of hoppers. It may be also sprayed directly on to the hoppers, since it kills both by contact and as a stomach poison. It is necessary to know the arsenious oxide content of the arsenite of soda which is used; the above formula refers to an 80 per cent. arsenious oxide content.

Other forms of arsenic, such as white arsenic, are sometimes used. Stock should not have access to sprayed areas. Sprays containing soluble arsenic are liable to burn foliage. The disadvantages of the spraying method are obvious, but with heavy pasture growth good results should be obtained. In the case of a pasture crop like lucerne, it is advisable to protect the crop by spraying a barrier area around it, rather than spraying the crop itself.

7. The poison bait method is widely used. A bait consists of an inert carrier, a poison, and an attractive substance. Bran is a useful and efficient carrier, but other convenient materials, such as chaff, chopped fodder, or sawdust may be used where bran is not available. The carrier should break readily into small pieces when the bait is distributed; it must not deter the insects from feeding on the bait. Bran has many advantages as a carrier and its high efficiency offsets its cost. Experiments should be made with suitable local materials.

Arsenical poisons have given the most satisfactory and consistent results; Paris green and sodium arsenite are generally used. The soluble forms of arsenic compounds kill the insects quicker than the insoluble forms. The solubility of certain compounds in 100 parts of cold water are given below:

White arsenic (Arsenious oxide) As_2O_3 ...	1·2 parts
Sodium arsenite Na_2HAsO_3 ...	Very soluble
Sodium arsenate $Na_3AsO_4 12H_2O$ ...	26·7
Calcium arsenate ...	Insoluble
Lead arsenate ...	Insoluble.

With soluble poisons the solution of the poison is poured over the bait carrier and thoroughly mixed; with insoluble poison the bait should be mixed dry with the carrier and then made into a mash with an appropriate amount of water.

The attractive agent in the bait greatly increases its efficiency. The evidence regarding the value of the use of molasses is conflicting; where this material cannot be obtained it would appear to be justifiable to use the bait without it. In addition to being attractive to the insects molasses assists in keeping the bait moist for a longer period. Damp baits are more attractive than dry ones; salt is sometimes added to baits in order to assist in keeping them damp.

Other substances have been used in baits as attractants, such as crushed fruits. Further experiments are necessary on this aspect of baits.

The following formula has proved to be an effective bait in Australia:

Arsenite of soda	...	...	½ lb.
Molasses	...	...	4 lb.
Bran	...	...	24 lb.
Water	...	...	2½ galls.

The arsenite of soda is dissolved in the water and the molasses added to the solution. The mixture is sprinkled over the bran, the whole being thoroughly mixed to form a crumbly mash. The amount of arsenious oxide present in the arsenite of soda is important; the formula refers to an arsenious oxide content of 80 per cent.

The bait is scattered over an area of about 30 ft. wide in front of advancing swarms of hoppers. The amount of bait required per acre will vary with the character of the area. About 10 lb. of bait (dry) should be sufficient, but in practice the amount used may be greater than this; if laid too thickly there is undue wastage of bait. The risk of poisoning stock is negligible if the poison bait is spread thinly as directed. Operators handling poison bait must observe common-sense precautions. Baits should be spread early in the morning; the hoppers become more active later in the day as the temperature increases. On cold days baiting is not so effective since the hoppers are sluggish.

(8) The application of poison dusts, both as stomach poisons and contact poisons, has been widely developed in several countries against certain insect crop pests. During the past few years experiments have been made on the use of arsenical dusts for the control of grasshoppers and locusts. This work is in an experimental stage and would appear to have a promising future.

A dust consists of an inert carrier and the active poison lime gypsun, talc, etc. are generally used as carriers. Arsenical compounds have been chiefly used as the poison.

Appropriate dusting machines are necessary. For small swarms the knapsack or hand rotary duster may be suitable. For large areas the use of the aeroplane is gradually being developed; suitable apparatus for distributing the dust is attached to the aeroplane.

The aeroplane method appears to be particularly suitable for large areas of unoccupied or sparsely-inhabited country. It will have only a restricted application in settled areas, owing to the difficulty of efficient localisation of the dust cloud. The latter is considerably affected by weather conditions, particularly wind.

Where swarms of hoppers are scattered, as is the case of the wandering grasshopper in South Australia, the areas requiring treatment would have to be clearly defined in order to reduce wastage in materials and loss of time. In order to manoeuvre the plane over these areas considerable ground organisation would be necessary. Under these conditions the method would be costly.

Experiments have been carried out more recently with a view to testing the effect of dusting flying swarms of locusts with dusts containing sodium arsenite. It is thought that the dust will effectively kill the insects by contact.

(9) Few experiments have been made on the effect of poison gases against grasshopper swarms. The method can have only a restricted application owing to the danger to animal and plant life.

(c) *Destruction of Winged Swarms.*—Certain of the methods referred to in section (b) may be used. Of these, the use of poison baits and poison sprays are generally adopted. In some instances destruction of winged swarms when resting at night is possible.

THE CULTIVATION OF RICE IN CEYLON*

UNLIKE the plantation industries of tea, rubber and coconuts, for which complete statistical information on areas and yields are available, there are in Ceylon no reliable data on village agriculture. It is estimated that about 800,000 acres of rice are grown annually, the actual area of land being less, as some land carries two crops a year. The latest official estimate of yield by revenue officers is 14 bushels (of 45 lb.) per acre. This figure is admittedly open to serious error, and since 1925 figures for yield have not been included in the statistics. There is reason for supposing that the estimated yield of 14 bushels per acre is too low, and this question will be referred to later. If the average yield is taken to be 20 bushels, the annual production is 16 million bushels of paddy (rice in the husk) or 8 million bushels of husked rice. This is equal to about 4·6 million cwt. The imports of paddy and rice into Ceylon for the five years 1929-33 in terms of husked rice have averaged 9·27 million cwt. It will be seen, therefore, that Ceylon produces about a third of the rice it requires. Why a purely agricultural country like Ceylon finds it necessary to depend on Burma for two-thirds of its rice requirements is due to the magnitude of the plantation industries, particularly of tea and rubber, and to some extent of coconuts. Not only do the plantation industries make use of land, much of which could grow rice or other cereals, but they employ a large labour force whose staple diet is rice. It must be added that it is to its plantation industries that Ceylon owes its prosperity.

In spite of the large areas under tea, rubber and coconuts, there are larger areas of jungle, scrub jungle and savannah capable of growing rice if irrigation-water can be supplied. The construction of new works for the supply of irrigation-water on a large scale will be costly and possibly uneconomic, but the production of rice can be and is being increased by the following means: (i) the restoration of ancient village tanks where old paddy land exists and where there is still a nucleus of population; (ii) the improvement of major irrigation-works and the construction of new channels to bring more land under cultivtaion; (iii) organized colonization schemes under major irrigation-works, where owing to malaria or other reasons land has not been taken up; and (iv) the adoption of improved methods of cultivation, which are being vigorously urged by the Department of Agriculture through propaganda and practical demonstration, and include the use of pedigree seed, improved implements, of green, farmyard and artificial manures, and the adoption of transplanting in those areas where this practice is suitable.

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* By L. Lord, Divisional Agricultural Officer, Ceylon, in *The Empire Journal of Experimental Agriculture* Vol. III, No. 10, April 1935.

Climate and Soils.—Rice is chiefly cultivated in the low country, but considerable areas are cultivated in the mid-country up to 2,500 ft. above sea-level. Rice is cultivated between 4,000 and 5,000 ft., but the area is small. The temperature conditions for the bulk of the rice area do not vary greatly. There is, however, considerable variation in the rainfall. Rice is grown all over Ceylon and the rainfall varies from under 50 in. to over 200 in. Under favourable conditions from 50 to 60 in. of rain distributed during the growing-season are sufficient for a 4-months' crop. More than half of Ceylon has a yearly rainfall of under 75 in., and in this part of the Island cultivation that depends entirely upon rainfall is precarious owing to the uncertainty of its incidence. Irrigation-water is generally utilized both to supplement and, in the dry season, to replace direct rainfall. Even in the wetter parts of the Island the run-off from land adjoining the rice fields is utilized. Owing to the risk of floods in the wet season large areas are cultivated under irrigation during the dry season. Generally speaking, there is sufficient rainfall for rice during both the north-east and south-west monsoons only in a small area in the south-west of the Island stretching, roughly, from Kandy in the mid-country to Galle at sea-level. But even here run-off from nearby land is utilized. During the north-east monsoon 5-6½ months' varieties are grown, and during the south-west monsoon 4-5 months' varieties. The seasons are known, in Sinhalese, as *maha*, and *yala* respectively, meaning long and short season. In the rest of the Island direct rainfall is insufficient during the south-west monsoon, when generally 3 motnhs' varieties are grown under irrigation. During the north-east monsoon 4 months' varieties are generally grown, to some extent with direct rainfall only, but generally with supplementary irrigation water. Table 1 gives an idea of the meteorological conditions in two dissimilar parts of the Island.

No systematic study of the rice soils has yet been made. Typical soils are clays or clay loams that can be puddled to retain water, and have an acid or slightly acid reaction. In the Eastern Province there are considerable areas of sandy-loam soils which produce a good crop when water is sufficient.

Irrigation.—Most of the paddy land is irrigated with water stored in large or small reservoirs, known as tanks. The thousands of tanks, most of them abandoned for centuries, in the northern half of the Island, bear witness to the magnitude of the facilities for irrigation in ancient times. Many of these tanks were constructed before the beginning of the Christian era, and modern engineering science is impressed by the ingenuity displayed in the construction of them and their channels. The channel from Kalawewa tank to Anuradhapura is 75 miles long. There were systematic irrigation schemes and small tanks were fed from large tanks. Most of the thousands of tanks are small, but many were (and are) large. The area of Minneriya tank, the largest, is 4,500 acres; Kalawewa, the second largest, covers 4,337 acres, and Nachchaduwa tank 3,920 acres. There is evidence for the statement frequently made by Ceylonese that at one time Ceylon was the granary of the East.

Most of the modern major irrigation-works are based on ancient tanks that have been restored and improved, and many of the ancient channels have been utilized. The area of land under major works actually sown in 1933 is given as 167,000 acres. Some of the area is cultivated twice a year, so the actual land area is somewhat less. Under smaller village tanks in the same year the area is given as 212,941 acres. Thus nearly half of the total rice area is irrigated by major works or by village tanks.

TABLE I

RICE CULTIVATION: METEOROLOGICAL DATA

District	Month	Total no. of days	Mean monthly temp. °F.	Maximum temp. °F.	Minimum temp. °F.	Mean daily sunshine hrs.	Rainfall in.
Baticaloa, 30 ft.	Mar.		80·2	87·6	69·7	8·4	3·15
a.s.l., SW.	Apr.		82·0	90·6	74·8	8·5	1·95
Season, 3 months'	May		83·6	96·2	74·6	8·0	1·84
rice. *Vellai perunel.* Irrigated.	June	90	84·8	97·7	74·6	7·5	0·96
Batticaloa, 30 ft.	Oct.		80·9	88·6	72·1	7·5	6·49
a.s.l., NE.	Nov.		79·4	90·1	72·1	6·4	13·51
Season, 4 months'	Dec.		77·9	84·1	70·5	5·8	16·48
rice. *Perillanel.*	Jan.		77·6	82·4	69·8	6·7	10·36
Irrigated when necessary.	Feb.	120	78·3	87·2	67·4	8·5	3·44
Kandy, 1,611 ft.	Apr.		78·7	89·4	65·8	6·3	6·83
a.s.l., S W.	May		78·3	91·1	67·6	5·7	5·78
Season, 4½-5 months'	June		77·0	88·1	66·2	4·1	9·45
rice. *Suduhinati.*	July	about	76·6	85·5	67·3	4·4	7·39
Irrigated when necessary.	Aug.	140	76·2	88·7	67·2	4·7	5·82
Kandy. 1,611 ft.	Sept.		76·2	86·6	64·5	5·5	6·05
as.l., NE.	Oct.		76·0	87·1	65·1	5·1	11·62
Season, 6-7 months'	Nov.		75·9	86·0	62·2	4·7	10·51
rice. *Mawi.*	Dec.		75·2	85·8	61·8	5·5	8·85
Irrigated when	Jan.		75·0	85·7	63·4	6·1	5·38
necessary.	Feb.	about	76·6	88·4	53·3	7·0	2·23
	Mar	200	78·4	89·2	64·1	6·9	4·20

Notes. (1) The figures given are means over a number of years.

(2) In the Batticaloa District sowing during the NE. monsoon generally takes place early in November.

During the SW. monsoon, when irrigation-water almost alone is relied on, sowing takes place from February to June, but a common time for sowing is from March to April.

Varieties.—Lists have been published of over 300 different names of botanical varieties, but there can be little doubt that many are synonyms. A complete study of the varieties has not been made, but those so far examined by Lord and Abeysundera [1] show that the *mawi* (aged 6 months) group of rices are similar to the Burma *midon* type, and the short-aged (3-4 months) rice like *hingti murungan*, *hinkaravel*, *illankalayan*, and *suduhonderawala* (5 months) are similar to the Burma *ngasein* type[2]. A small round-grained variety known as *podiwi* (similar to the Indian *muthusamba*) with a white testa is grown on a small scale and is esteemed as a table rice. The striking peculiarity of Ceylon rices compared with rices in other countries is that they have almost invariably a red testa. Most of the varieties grown on a large scale are unawned.

There is a belief among cultivators that certain varieties are best suited for certain soil conditions, but it is remarkable how well one variety will adapt itself to different soil and climatic conditions. The pedigree selection *perillanel* 26014 may be quoted as an example. This selection gives comparatively high yields on sandy soils at Batticaloa at sea-level and on clay loams in the Province of Uva at 2,000 ft. above sea-level. Another pedigree selection, *vellai illankalayan* 28061, has proved to be a higher yielder than the village varieties over most of the northern half of the Island. There is little doubt that the number of so-called varieties at present grown could be divided by ten without loss of yield and with a very definite gain in uniformity.

Unfortunately, in a country like Ceylon, with large differences in rainfall, different-aged varieties are essential. A variety for a district depending upon direct rainfall must be of such an age that it will flower during a period of light rainfall and mature in a comparatively dry period. The time of sowing cannot be altered very much; it depends on the start of the rains. Under irrigation it is the general custom to grow a 3-months' variety during the dry season and a 4-months' variety during the wet. Other things being equal, the yield of a variety is positively correlated with age.

There are now available for most of the different conditions under which rice is grown in Ceylon, pedigree selections yielding from 15 to 30 per cent. more than the local village varieties. The technique used in selection has been described by Lord [3]. These pedigree selections are now becoming popular with cultivators. Most of the rice produced is husked in a primitive mortar in the home. Until a milling industry using modern machinery is developed, there is no reason why the present red rices should be replaced by white.

Size of Holdings.—Here, too, no reliable statistics are available, but it is believed that the size of the holding worked by one man is from 2 to 3 acres. This does not apply to the Eastern Province where holdings of over 25 acres are common and where one man will work from 5 to 7 acres. The small size of the holdings, apart from the Eastern Province, is due to lack of land and the popularity of paddy cultivation among the Sinhalese, who consider that more prestige is attached to this than to other forms of manual work.

In the east and north of the Island comparatively large rice-fields are found, many being as large as half an acre and a few slightly larger. Even here the tendency is to construct small fields rather than to undertake the necessary levelling of the land to construct large fields. In the rest of the Island rice-fields are very small and many of the picturesque terraced rice-fields in the mid-country are no larger than 10 or 12 sq. ft.

Cultivation.—In small fields the land is tilled by hand with an implement known as a 'mamootie', which is a heavier and larger variety of hoe. It produces the same effect as digging with a spade, the necessary force to penetrate the ground being obtained by swinging the implement over the head. In larger fields tillage is done either by a primitive plough drawn

by cattle or buffaloes, or by the trampling of a team of six or eight buffaloes driven round and round the field. The latter method is chiefly used on marshy land where animals sink in up to their bellies, and on flooded land where it is difficult to see where the plough has been. But in many places fields are prepared by trampling that could easily be ploughed, because the buffaloes cost less than plough cattle. Plough cattle are small and generally uncared for, but many are quite able to draw a light mould-board plough like Ransomes 'Ceres' or 'P.I.K.' The comparatively high cost of these ploughs, however, precludes their general use. A simple wooden harrow pulled by two bulls is used in Burma to puddle the soil after the first ploughing. The writer has introduced this implément into Ceylon, but it has not yet become very popular. Its use ensures better and cheaper puddling of the soil. After two or three ploughings or tramplings with one or two inches of standing water on the soil, the field is levelled either by hand-levellers resembling a wooden rake without teeth, or by a plank drawn by two cattle. About this time the bunds surrounding the field are generally plastered with mud from the field to fill up crab holes and to render the bunds more impervious to water. After levelling, small drains are made to remove any standing water. Germinated seed is broadcast at the rate of from 2½ to 3½ bushels per acre. In germinating the seed it is first soaked in water (in gunny bag) for 12—23 hours, after which the bag is put in a shed and covered with moist empty bags or with leaves. Sometimes light weights are placed on the top. After from 4 to 7 days, when the radicle and plumule have emerged, the seed is sown. In parts of the Eastern and Northern Provinces appreciable areas are sown during the NE. season with ungerminated seed. The rather sandy fields are ploughed, without flooding, at the start of the rains, and irrigation water is not issued until the rainfall has become inadequate. With good cultivation 2 bushels per acre of seed paddy are ample.

The seed used is mainly that grown during the last corresponding season, which means that the seed is from 5 to 8 months old. The germination rapidly lessens after 10 months from harvesting. Newly harvested rice seed, except the seed of dead-ripe, short-aged, varieties cannot be used for sowing until 2 or 2½ months after harvest.

As a result of the propaganda efforts of the Department of Agriculture, the acreage transplanted, though small, is increasing. Experiments in Ceylon [4, 5] have shown that, with a 6 to 7 months' rice, transplanting increases the yield by from 30 to 46 per cent., and is profitable. With the 3 to 4-months' varieties, which occupy most of the rice area, it is doubtful if transplanting will be profitable. Weeding, with or without thinning the plants, a month after sowing, is carried out in a few districts only. Manuring will be discussed in the following section. The crop is harvested about one month after flowering by means of a serrated sickle-shaped knife. It is threshed by trampling with buffaloes, and winnowed by wind. Threshing is done on the field or on adjacent high land, and although in many places threshing floors are carefully beaten flat and plastered with cattle-manure, frequently the floors are roughly made, and the rice from these floors contains sand and small stones, which are objected to by consumers

as they cannot easily be removed before or during cooking. Efforts are being made to encourage threshing on jute or palmyrah-leaf mats, and the construction of permanent brick and cement communal threshing floors is advocated.

Manuring.—The application of manures to rice-fields is the exception rather than the rule, although green-manuring is fairly extensively practised by Sinhalese cultivators in the Kandyan districts, and by the Tamils in the extreme north of the Island. Green-manure crops, like *Crotalaria juncea.* are not grown for the purpose of green-manuring. Among the trees whose leaves are used are *Azadirachta indica*, *Cerbera odollam*, *Borassus flabellifer*, *Erythrina lithosperma* and *Gliricidia sepium.* Wild Sunflower (*Tithonia diversifolia*), which grows luxuriantly and is found wild in the mid-country, makes an excellent green-manure and its use is extending. The effects of green-manuring on yield have been investigated by Haigh and Joachim [6] and Lord [8, 9], and the chemical changes in the soil by Joachim and Kandiah [7]. It was found that the green material gave its maximum effect if applied under anaerobic conditions (*i.e.*, after the soil had been flooded) and within a few days of broadcasting or transplanting. Applications of 5 tons per acre gave increased yields of 30 and 29½ bushels. An application of 1 ton per acre is more likely to be used. In two experiments in different years this dressing produced increased yields of 12½ and 15 bushels per acre. Farmyard manure is seldom used, is not available in large amounts, and its quantitative effect has not been studied. Its use on rice-fields is being encouraged. The effect of artificial manure on the yield of rice has been studied by Lord [8, 10, 11, 12] and Haigh and Joachim [5, 6]. The effect of manures on the composition of the paddy crop has been investigated by Joachim, Kandiah, and Panditteseker [14].

Generally, it has been found that phosphoric acid is the limiting factor in Ceylon soils, and that the rice crop responds both to phosphoric acid and to nitrogen in the form of sulphate of ammonia or ammonium phosphate Excluding the results of manurial trials in the Eastern Province, an examination of the others shows that an application of 1 cwt. of ordinary superphosphate or of bonemeal may be expected to give on an average an increase of from 10 to 15 bushels with a normal crop, and a residual effect of about half that amount. Sulphate of ammonia alone has not given profitable increases, but from dressings of 93-104 lb. per acre of both wide and narrow ratio Ammophos, increases varying from 10 to 25 bushels per acre were obtained. There is evidence to show that the wide ratio ammonium phosphate was more effective than the narrow. There was some residual effect. Recent experiments in the Eastern Province [12] have shown that at three widely separated centres there was at two centres no response, and at one little and non-significant response, to phosphoric acid. Three and four-months' rices were grown and 1 cwt. of concentrated superphosphate (42 per cent. P_2O_5) was applied per acre. The experiments, which were identical at the three centres, included also applications of 1 cwt. per acre of Nicifos (22/18) and Ammophos (13/46). At two centres Nicifos gave significant increases of respectively 11·3 bushels * per acre (4-months'

* Bushels of 45 lb.

rice) and 9·3 bushes (3-months' rice). The response to Ammophos was slightly less. At the third centre the increase due to Nicifos was 10·8 bushels per acre, but the experiment was just not statistically significant. It would appear, therefore, that in the soils of the Eastern Province (and perhaps in other soils in the Island) nitrogen is the limiting factor. Experiments have already been laid down to determine this. For the present it may definitely be said that the application of 1 cwt. per acre of one of the ammonium phosphates will pay when the price of paddy (rice in the husk) is not less than Rs. 1-50 per bushel. In those where rice responds to phosphoric acid alone, manuring is profitable even with a price of Rs. 1 per bushel. There is, however, little likelihood of artificial fertilizers being used on a large scale unless the price of paddy rises to somewhere near Rs. 2 per bushel.

Generally, manurial experiments are carried out in small bunded plots with each replication complete within one field. It has been shown [13] that if a replication extends over two or more fields, the standard error may be largely increased. It has been noticed that where small bunded plots are used, particularly in places where drainage is difficult, the levels of the plots may vary. If heavy rain falls soon after sowing, there may be standing water on some plots and not on others. Standing water at this stage may retard growth, or even destroy the plant, perhaps by burying the seed, with tiny plumule and radicle, under fine mud. Two manurial experiments carried out by the writer in bunded plots were spoiled by rain soon after sowing. Recently, plots have been used without bunds but with a 3-foot space between plots in the middle of which a shallow drain is constructed. This method avoids or reduces errors through differences of level and, judged by the magnitude of the response to fertilizer, there is little if any wash from one plot to another. The space between the plots is sown with rice. Owing to the small size of the fields in Ceylon, experimental plots must necessarily be small if (as is so desirable) a replication is to be laid down in one field. Plots of 1-80 acre, of which an inner area of 1-100 acre is harvested, replicated from four to six times give sufficiently small experimental errors.

Irrigation-water.—No data have yet been obtained on the optimum amount of water necessary for paddy. Generally the Irrigation Department allows 6 acre-feet for a dry-season crop of from 3 to 4 months. Although a fair amount of this water is lost in the channel by percolation, it is ample for a good crop. In parts of the Island it is the custom to allow irrigated fields to dry out after sowing to such an extent that cracks appear in the soil, in the belief that the aeration thus provided is beneficial at this stage. Two pot experiments were carried out to ascertain if drying out had any effect on yield. Three treatments were given: (a) periodic drying as practised by some cultivators, (b) continual submergence from ten days after transplanting until two weeks before harvesting, and (c) a combination of (a) and (b). In the first experiment no significant differences were obtained, but a second experiment in which the treatments were replicated eight times and which satisfied the requirements of the Z test gave the following comparative yields: periodic drying 100, continual submergence 131, and a combination of the two treatments 106. Continual submergence

from an early stage in the growth of the plants not only gives increased yields but reduces weed-growth, and prevents any serious damage from the Swarming Caterpillar (*Spodoptera mauritia*), which is found chiefly in those areas where drying out of the soil is practised. The depth to which plants are submerged varies from 3 to over 12 in., depending on the height of the bunds (many are made too low), the amount of water available, and the presence or absence of drainage facilities. A depth of 6 in. is considered desirable.

Cost of Cultivation.—Almost all the rice in Ceylon is grown either by small owner-cultivators or, more generally, by tenants on a share system. The share system of tenancy is not conducive to good cultivation as the tenant knows that he will only get half of any increased yield due to manuring, transplanting, or better tillage. The share system, however, appears to be unavoidable; a landlord will not consider cultivating by means of hired labourers on daily pay. In the share system of tenancy the tenant is financed by the landlord. Owing to the different systems of share-tenancy and the numerous loans which are made, generally in kind at 50 per cent. interest, no reliable figures of cost of cultivation under share-tenancy conditions are available.

The cost of cultivating with hired labour, using mould-board ploughs and Burmese harrows, has been recorded at two paddy-seed stations in the Eastern Province. Although these costs are undoubtedly somewhat greater than the cost of cultivating under a share-tenancy the figures may be of interest.

TABLE II

COST OF RICE CULTIVATION PER ACRE

Operation	Station			
	Illupadichchenai		Sengapadi	
	Rs.	cts.[1]	Rs.	cts.[1]
Repairing bunds	0	90	1	88
Ploughing and harrowing ...	8	80	7	86
Levelling	—		2	62
Sowing and making drains ...	0	40[2]		
Reaping	2	60	1	88
Carrying sheaves and stacking ...	1	95	1	52
Threshing	5	46	4	90
Winnowing	1	92		
Fencing	1	99	1	00
Watching and Irrigating ...	7	39	9	20
Water rate	1	30	0	50
Seed Paddy, 2 bushels at Rs. 1·50 ...	3	00	3	00
Total	35	71	34	36
Yield per acre in bushel of 45 lb. ...	30	00	37	00
Wages, men, per day	0	60[3]	0	50
Plough-bulls per pair per day ...	0	75	—	
Plough-buffaloes or bulls per pair per day	—		1	00

1. Rs. 1=1s. 6d. 2. Dry sowing of ungerminated seed. 3. 75 cts. at harvest.

The rent of land varies largely, but a general rent is between Rs. 7 and Rs. 15 per acre; the price of unhusked rice for the past two years has varied between Rs. 1 and Rs. 1-50 per bushel. At present a movement is on foot to increase the price of rice, either by increasing the existing moderate import duty, or by a system of quotas.

Yields.—It has already been stated that the official estimate of the yield of rice* is 14 bushels per acre, or less than half the yield in India, where conditions are not greatly dissimilar. Although the estimate of 14 bushels is too low, there is little doubt that average yields in Ceylon are really lower than in India. This may be ascribed to the following reasons: (i) A proportionately greater area of short-aged rices is grown in Ceylon and, other things being equal, the longer the age the higher the yield. (ii) Ceylon figures for area include twice over land that is cropped twice a year, and it is belived there is more double cropping in Ceylon than in India. Double-cropped land per crop yields less than once-cropped land. (iii) Appreciable areas of land in Ceylon fail to mature a crop or a normal crop, owing to failure of rains or shortage of irrigation water. (iv) Transplanting is widely practised in India. In Ceylon it is the exception, and it is doubtful if transplanting is profitable with short-aged varieties. A more reliable estimate of yields is contained in the report of the Director of Irrigation, and in 1931 the yield of over 161,000 acres of rice under major works is given as 21·2 bushels per acre. Of these figures the area is based on measurement, the yield on estimates and not on crop cuttings. Estimates of yields, which are made after consultation with cultivators, are invariably on the low side as both landlords and tenants are reluctant to divulge the true yields. Excluding areas which fail to mature a normal crop due to lack of water, the yield of rice in Ceylon is probably between 20 and 30 bushels per acre. The following yields, using 3-4 months' pedigree selections, and with good cultivation but no manuring, have been obtained recently in the Eastern Province: 354 bushels from 10 acres in 1932-33 (35·4 bushels per acre), 297 bushels from 10 acres in 1933-34 (29·7 bushels per acre), 438 bushels from 12½ acres in 1933 (35 bushels per acre), 465 bushels from the same area in 1934 (37 bushels per acre). In 1934, at the paddy-seed station of Tamblegam, which is situated on good soil, the following high yields were obtained, without manuring, from a broadcasted crop: 3 month's rice, 53·2 bushels per acre; 3¾ months' rice, 71·3 bushels per acre. There is evidence from all over Ceylon that with good cultivation yields of 30 bushels per acre can be obtained without difficulty.

Pests, Diseases, Weeds.—Insects are much more important than fungus diseases, but even the damage caused by insects is not extensive. In some areas, where bunds are low and irrigation-water is not issued at the right time, serious damage may be caused by the Swarming Caterpillar (*Spodoptera mauritia*). The Paddy Fly (*Leptocorisa varicornis*) is universal, but the damage caused is noticed only in small patches, which mature before or after the bulk of the crop, or in small areas of rice-land surrounded by extensive tracts of jungle and grassland. It is possible that the damage

* Except where otherwise stated, 'rice' in this paper means 'rice in the husk' or 'paddy'.

by Paddy Fly is more than is realized. The stem-borer (*Schoenobius bipunctifer*) is also universal, but it is not found in large numbers, and the damage caused is slight. Two pests of stored rice are Paddy Moth (*Sitotroga cercallela*) and the Paddy Weevil (*Calandra oryzae*). The former attacks rice in the husk only. At Peradeniya the germination of rice in four months was reduced by 15 per cent. due to damage by these two insects. Fungus diseases like *Rhizoctonia solani* and *Sclerotium oryzae* [15] cause, on the whole, little damage, but under certain conditions the latter may become serious. At Peradeniya, for example, the young plants of a foreign rice were almost completely destroyed by this disease.

In the sparsely populated parts of Ceylon the far too numerous wild elephants and pig do considerable damage to the rice crop, and elephants occasionally kill cultivators watching their fields at night. Land crabs (*Paratelphusa oziotelphusa hydrodromus*) are found in large numbers in paddy fields in Ceylon. They eat young plants and the seed-rate is heavy to make up for this loss. Crabs live in burrows in the bunds and the most serious damage occurs in the terraced cultivation of hill-sides, where the burrows may form channels for the water impounded in the field. Not only is water lost, but the passage of the water weakens and in time destroys portions of the bund. Crabs can be trapped in earthenware pots whose diameter in the middle is much larger than the diameter of the mouth. The most effective way of catching them is by boys who can catch from 100 to 200 per day. On an area of about 5 acres at Peradeniya 55,925 crabs were caught in the course of one year. Except where breeding or fine experimental work is in progress, it is not considered economic to attempt to reduce the number of crabs by traps or by boys.

Fimbristylis miliacea and several species of *Cyperus* are very common weeds on rice-fields and at times are present in such abundance that yields are greatly reduced. *Panicum crus-galli* is also common but not so serious. Good preliminary cultivation, together with shallow submergence of the fields as soon as the plants are about 3 in. high, increasing to 6 in. submergence as soon as the plants are about 9 in. high, will check or prevent weed growth. Where water is not available for submergence in the early stages of the growth of the plant, weeding is advisable, but is seldom done outside the Kandyan districts.

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LOCUSTS AND A RATIONAL ANTI-LOCUST POLICY*

THE layman's conception of locusts is that of insects which suddenly appear from somewhere in enormous swarms darkening the sky and disappear again leaving bare ground in place of rich pasture and abundant crops. The mysterious origin of the swarms, their enormous size and the countless numbers of individuals of which a swarm is composed, all create an impression of utter impossibility of ever defeating this pest. It is exactly this spirit of hopelessness which is typical of the anti-locust policy over practically the whole world. In the great majority of countries subject to periodical locust ravages nothing is ever undertaken to prevent the appearance of swarms, and no attention is paid to locusts until the invasion reaches such an extent that the battle against it can be counted as lost before it begins. The organization for defence is designed only to save the crops and to minimize the losses. Enormous sums of money are spent on such defensive measures, and not always with success. In the Argentine, for example, the amount spent on locust control during the period 1897-1933 totalled over £11,000,000. This means that more than £300,000 on the average were spent every year, and in some years the expenditure rose to nearly a million pounds. In the Union of South Africa £1,125,000 were spent on locust control during the years 1920 to 1928, or £125,000 annually, and in the year 1934 alone the cost was £1,400,000. To these expenses must be added the cost of tens of millions of working days spent in fighting locusts by the population, who are obliged to do so by law. It should be clear that the economic aspect of the locust problem is a very serious one.

An objection can be made that locusts are not a universal pest, but occur only in some countries. As a matter of fact, however, on every continent there are only a few countries which are safe from these pests. In most of Europe, it is true, no locust swarms have occurred for nearly a century, but the Mediterranean countries are still suffering from them regularly, and a heavy outbreak is developing in southern Spain at the moment. On the south-eastern fringe of Europe, in the steppes of Russia and the Caucasus, locusts are a regular pest. Turning to Asia, the whole southern half of this enormous continent, except the highest mountains and plateaux is ravaged by locusts from time to time; and the northern grasslands of Siberia are subject to a regular plague of grasshoppers, which are the nearest kin of locusts. The continent of Africa is wholly in the danger zone, and the devastations caused there by locusts during the last few years are well-known. In South America, Argentina is not the only country that has to pay a heavy tribute to locusts, and other states of that continent suffer no

* By B. R. Uvarov, Imperial Institute of Entomology in *The Empire Cotton Growing Review*. Vol. XII, No. 3, July, 1935.

less heavily. In North America, as in Siberia, locusts give place to grasshoppers, but the problem of their control is essentially the same. The smallest and the remotest continent of Australia, although still little developed agriculturally, has already had several warnings of impending catastrophes, and only last year wide areas were devastated by locusts.

Naturally, the species of locusts are not the same in every continent and country, and their habits vary to some extent, but the essential features of the locust problem are amazingly similar everywhere.

The first characteristic of the problem is that the areas covered by locusts in their migrations are very much greater than in the case of most other insects. As a result swarms arising during a given season in one country may soon spread beyond its borders and invade distant territories. An excellent example is offered by the movements of the Migratory Locust in Africa during the recent outbreak. It is now established beyond any doubt that the first small swarms of this locust arose about 1926 in the inundation areas of the Middle Niger, south-west of Timbuctu, in the French Sudan. Spreading gradually and increasing in number and size after each breeding season, the swarms soon invaded the whole of West Africa, spread into the Anglo-Egyptian Sudan, then swept into East Africa and crossed the continent once again from Rhodesia into South-West Africa. These developments may sound almost fantastic, but they have been followed year by year, and it took only five years, during which ten successive generations were produced on the way, to accomplish a double crossing of the continent and to invade the greater part of it.

Similar extensive wanderings of locust swarms have been repeatedly observed in other countries, and their complete disregard of international boundaries suggests the futility of ever finding a solution of the locust problem, except on an international basis.

The necessity of international co-operation in locust control has often been stressed, but the type of co-operation usually visualized is as useless for the real solution of the locust problem as the sporadic defensive measures practised in each country. It is often suggested in the countries spending large amounts on locust control within their own borders, that a similar energetic anti-locust policy in every other country would lead to a speedy and complete extermination of the pest. This is a complete fallacy, since the numbers of swarms, to say nothing of individuals in them, are so great that a simple calculation should show the impossibility of completely exterminating them. Indeed, if a pair of locusts produce only a hundred offspring (and this is a most conservative estimate) the destruction of even 98 per cent. of the offspring would result in the number of locusts remaining the same as before. There is no doubt that this percentage of destruction is practically, unattainable, except in the most densely populated and highly civilized countries. When a continent like Africa has to be cleared of locust swarms wandering over its deserts, dense bush and swamps, it cannot be hoped that success can be achieved even by a universal anti-locust campaign. The cost of such a campaign would be, of course, expressed in astronomical figures, and in some of the most dangerous areas there will not be found sufficient man-power to carry it through.

Clearly, other strategical schemes have to be devised to deal with this formidable pest. A sound basis for such schemes has been provided by some results of the more recent studies on the problem. We have seen already that in the case of the Migratory Locust the invasion involving the greater part of the continent of Africa has originated in a single relatively small area. Again, it is almost certain now that the swarms of the dreaded Red Locust, now invading practically the whole of Africa south of the equator, arose some years ago in two or three small areas in Northern Rhodesia and Tanganyika Territory. In the case of the Desert Locust, which constitutes a grave menace to crops and most particularly to cotton, in West Africa, the Sudan, Iraq and India, there is every reason to hope that the original sources of its outbreaks will be discovered before long, some of them being already known. The swarms of the Moroccan Locust, a dreaded pest of crops in all Mediterranean countries, in Iraq, Persia and Turkestan, may spread over whole provinces, but swarms have their origin in narrowly defined areas, with peculiar soil and vegetation conditions. No comparable investigations intended to discover the original sources of swarms have been organized in other parts of the world, but even the incomplete knowledge in our possession of the locust problem there, leaves no doubt that the same state of things will be found everywhere. Outbreaks of locusts always commence by the formation of a few swarms in relatively small areas, with peculiar natural conditions, and the invasion then gradually spreads over the whole country and beyond its borders.

The importance of this general finding for devising a sound anti-locust policy is not difficult to understand. It means that once the *outbreak centres*, as they are called, are located, it would become a relatively simple matter to keep them under constant observation, and to suppress the incipient outbreak in their earliest stages, when the swarms are neither large nor numerous. This policy would result in effective *prevention of invasions*, which is, of course, vastly better than the purely defensive policy which has been, and still is, practised in all the countries.

The cost of the preventive policy is certainly well under that of controlling, or attempting to control, the swarms which have spread over the whole country, while in addition all losses to crops would be eliminated.

The difficulties in organizing a preventive control of locusts, as outlined above, are mainly psychological and political. It is a common human failing that a danger is seldom realised until it is too late, and it is easily forgotten when it is past. Since locust swarms appear only periodically with clear intervals of several years it is easy to persuade those whom it concerns to spend even a small amount in order to prevent an invasion when there is as yet no sign of it. Once the swarms appear and a panic sets in, the costs are not counted, money and labour are wasted in the hopeless struggle against an overwhelming enemy. When the swarming period is over a victory is proclaimed, and it becomes practically impossible to convince those in authority that the respite is only temporary and a new invasion is certain to come within a few years. It finally comes "unexpectedly", and the whole story begins all over again.

Until recently, this short-sighted policy had its justification in the insufficient knowledge of the habits and the sources of locust swarms. Now, as we have seen above it has been convincingly demonstrated with regard to several locust species that the policy of prevention can be based on the soundest possible foundation.

The first step towards such a policy in the case of each species of locusts would be a thorough investigation of the course of invasions, in order to discover the outbreak centres. Owing to the disregard of all boundaries by locust swarms, these investigations must be international in their scope and cover the whole territory over which the particular locust species can migrate. It is exactly on this basis that the locust investigations in Africa and Western Asia have been organized by the British Government. The countries within that immense territory agreed to submit monthly reports on the locust situation to the Imperial Institute of Entomology, London, which is recognized as the International Centre of Anti-Locust Research. These reports, accompanied by maps showing the breeding places and the movements of swarms, are carefully studied, and general maps and reports are prepared. These summary reports permit the Institute specialists to discover the main lines and directions of migrations, as well as the areas suitable for breeding. By following the reports back to the earliest stages of the invasion, it proved possible to trace the swarms to their original sources or the suspected outbreak centres.

The next step was to investigate these supposed outbreak centres on the spot to define them more closely. Several entomologists entrusted with this task were sent by the British, French, Indian and Belgian Governments to carry out these investigations. Some areas have already been surveyed and important practical conclusions have been reached, but the territories to be studied are very extensive and some of them difficult of access. The work is, therefore, not yet accomplished, though the end can be visualized within the next few years.

With regard to one locust, however, the Migratory, the task of preliminary surveys can be considered completed, and the problem of that locust is already ripe for a practical organization of preventive control. It is, however, one thing for the scientists to show the rational way to the solution of a problem, and quite another to hope that the necessary steps will be taken to reach it. In this particular case the difficulties in the way of practical steps are aggravated by the necessity to create an organization which would be international in its scope. When a single outbreak area presents a source of danger to the whole continent, it is only natural that all countries should take an active part in organizing the permanent control in that area. The task of creating such a permanent organization appears a difficult one, but it belongs to the sphere of politicians, not of entomologists.

The case of the Migratory Locust in Africa is, however, an extreme one. With some other species the problem is less formidable, since they are more localized, and often an outbreak area supplies locust swarms only to a single country. Such is the case, for example, with the Moroccan Locust, a notorious pest in some cotton-growing countries. The present

writer's investigations in Turkey and Iraq, and M Pasquier's detailed studies in Algeria, proved definitely that this locust can be easily kept under control in a single country. Indeed, an organization for the supervision of outbreak centres is already functioning in Algeria, and there is every reason to think that this means the end of invasions of that country by this locust. The cost of the permanent organization, which should be counted as an insurance premium against invasions, is very slight, compared with the periodic expenses of controlling the invasions. Unfortunately, other countries, even where the preliminary research work has been done, still prefer the time-honoured system of waiting for swarms to begin their ravages before anything is done to control them.

To conclude, the investigations and the experience of the last few years go a long way to prove that the great locust problem is not impossible of solution. This solution can come, however, only through a broad organization of research into the original sources of outbreaks. The investigations should supply the essential facts for developing a comprehensive preventive policy in the natural area of each locust species. In both stages of work, the success depends on an effective international co-operation, and on an efficient central organization. Given these two conditions, the locust problem will soon lose its tremendous importance, though a constant vigil will be necessary in the outbreak areas.

It is a hopeful sign that the idea of international co-operation in anti-locust research designed to develop a preventive policy is now finding an almost universal recognition. This policy has been fully endorsed by an international locust conference held in London in 1934, at which thirteen countries were represented. At the next conference, to be held at Cairo in 1936, it is hoped to extend the international anti-locust schemes to all the countries of the world suffering from this oldest and greatest enemy of agriculture.

WATER HYACINTH*

IT is well known how this exotic weed has become a pest of the countryside. This pest has rapidly spread in its country of adoption. The plant is eminently fitted for life in water. The long and ample roots act as ballast. The swollen leafstalks act like floats and the hoodlike leaves as sails and the plant careers about on the water surface, thus being helped in its distribution.

There are two ways of reproduction. The main rootstock produces slender offshoots, which end in a rosette of leaves and a tuft of roots. If the slender stalk breaks on account of strong breeze or waves, the broken rosette becomes an independent plant. The plant thus multiplies without any seed production and this method of multiplication is so common and so fast that it is regarded as the only way of reproduction. In clearing operations, care must be taken to remove all traces of this plant because any joint or rootstock left in water will soon lead to the reappearance of the plant in the cleared stretch of water. In fact the spread is so quick that it has been considered a mysterious process and has led to the supposition that even roots reproduce. This belief is certainly wrong as has been proved by experiment. This mode of asexual reproduction prevails wherever the water hyacinth occurs.

There is, however, a second, though not so apparent or common, method of reproduction and that is by seed formation. In hot and humid regions like Orissa and Burma it has been seen that water hyacinth appears in tanks which were scrupulously cleared. This was mystifying the executive officers in charge of clearing operations till seedlings were observed. The seedlings appear on wet mud on the tank-sides and as the water level rises, the tops of seedlings break away from the rootstock and float up. These floating rosettes produce new roots and become independent floating plants ready to reproduce by producing stolons which break off.

It is clear, therefore, that this mode of reappearance of the weed should be borne in mind in clearing operations. It is not sufficient to take out all the plants and destroy them. One must be vigilant from year to year, as the weed is likely to appear from seeds which have been lying at the bottom of tanks. It has been found that seeds may be dormant for several years, at least seven years, without losing their vitality, when, in any year of drought, the tank dries up, the seeds germinate after the first shower of rain. The seedlings grow rapidly with the rise in level of water up to a limit and then they get submerged. In a day or two the seedlings break off the rootstock neatly and float up. Near the clean surface of breakage new adventitious roots come and the plants are established as floating organisms.

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* By P. Parija, M.A., I.E.S., Professor of Botany, Ravenshaw College, Cuttack.
in *Agriculture and Live-stock in India*, Vol. V. Part II—March, 1935.

If the tanks are to be kept free from water hyacinth they must be cleared from year to year till the dormant seeds are exhausted. The question is as to the time of the year at which clearing must be done.

The most suitable time will be suggested from the facts of seed production and germination which are given below. The water hyacinth flowers almost throughout the year. Flowers are particularly abundant during the rains and the spring. When the flowers wither, the spike bends down in the form of an inverted S and often its tip dips into water.

Although careful search has been made in these plants for fertile capsules in spring and early rains, no capsules have been found. Fertile capsules appear only towards the end of October and November. The temperature at this time seems to be suitable for seed formation. These capsules burst when mature and discharge the seeds into water. The seeds are heavier than water and sink to the bottom of the tank or pool and lie dormant there. If in summer the bottom of the pool dries up the seeds lying there sprout after a shower of rain. It will thus be seen that the danger from seeds can only arise in autumn when the fruits mature. If clearing can be done in August and September, the flowers cannot get a chance to set seeds and the danger of re-infection from that source can be avoided.

One may be tempted to clear the seedlings early in the rains, but the difficulty is rather great. First of all, the seedlings are likely to be mistaken for grass for one or two months from sprouting. Secondly, even when they float up after submersion, they may lurk among other water weeds and make the search difficult and tedious. All this can be got over if clearing is done after the plants attain maturity and before they get seed.

Another way of checking seedlings is to keep the tanks, etc., full of water throughout the year, but that is not practicable.

As to the method of clearing, there seems to be only one sure method and that is mechanical. Chemical spraying in order to be effective must consist of strong chemicals and these introduce other complications like killing water animals and making the water poisonous for cattle. Mild spraying only checks the growth. Mechanical clearing should be thorough and care must be taken to ensure killing the plants thus collected. Otherwise a chance rootstock left alive is capable of repopulating the whole stretch of water in one or two years. This plant has remarkable power to adopt itself to mean dry situations as well as in free water. A rootstock thrown in mud will strike roots and as the mud dries, the plant adjusts itself to a land life and waits for the chance of getting into water when it comes. Although attempts at clearing have been repeatedly made, despairing failures have resulted from the presence of seeds in the mud and also from neglected living rootstocks. The clearing operations in Orissa had the merit of being very thorough. The authorities were aided by District Board by-laws and negligent owners of tanks and pools were prosecuted.

REVIEWS

SOIL FERTILITY

"Biological Processes in Tropical Soils"—*by Steven Corbet, W. Heffer & Sons Ltd., Cambridge, 7s. 6d.* nett.

THE conservation in tropical countries both of the top soil itself and of its fertility are subjects that are increasingly engaging the attention of planters and agricultural scientists, and the complexity of the problem of conserving soil fertility is only lately becoming generally realised. The book by Mr. A. Steven Corbet recently published is a welcome addition to the literature on these subjects. The part played by the soil micro-organisms in the loss and gain in the nitrogen content of soils and the effect and importance of tropical sunlight on soils are subjects of which our knowledge is increasing daily and Mr. Corbet's account of his own investigations and conclusions and of the recent investigations of others is both opportune and valuable. The practical considerations which form the final chapter of the book and which are of importance to tropical agriculturists and planters are based on the following statements: "(a) A re-statement of Jenny's law to the effect that the nitrogen and organic matter of the soil varies inversely with the soil temperature and the amount of solar radiation received. (b) At temperatures below 25°C (77°F) there is an accumulation of organic matter in the soil but at temperatures above this humus decomposition outpaces its formation."

The author's discussion of such subjects as the burning of cleared land, the use of leguminous and co-called natural cover crops, the "forestry" or "Birkemose" system of rubber planting and the effect of fertilizers on soils affords no encouragement to the advocates of clean weeding. It has apparently been shown in Malaya that rubber planted on land where stumps have not been removed suffers less from *Fomes lignosus* than rubber planted on land where stumps and as many roots as possible have been removed. This work has been criticised and further investigations are necessary but Mr. Corbet's discussion of the results is bound to arouse interest. The following statement is also of particular interest to Ceylon: "If the long view be taken, there can be little doubt that it is advisable to maintain rather than to dig in a growing cover, for it may be supposed that the soil nitrogen content will be slowly but surely increased by addition of dead leaves etc., as the shade is increased. It has already been pointed out that a fall in the potential nitrogen level of the soil as a result of removal of shade appears to be accompanied by release of the excess nitrogen largely in the gaseous form, in which state it cannot be assimilated by growing vegetation". Precise experiments to determine the best treatment of a cover crop are extremely desirable in Ceylon.

This book is written with special reference to Malaysia but most of the chapters including those on the soil fauna, soil micro-organisms, soil organic matter, the nitrogen cycle, Jenny's Law, and some practical considerations, are equally applicable to Ceylon conditions. The arrangement of the book is excellent. Each chapter has a summary and its own list of references, and the appendix contains sections on standard methods employed for the examination of soils, classification of bacteria, classification of fungi and a bibliography.

The disastrous effect of solar radiation on organic matter and nitrogen is emphasized by the author. This effect is by no means generally realized; it can at present be observed on the Experiment Station, Peradeniya, where an experiment in the eradication of couch (*Panicum repens*) and kora (*Cyperus rotundus*) by bare-fallowing with periodic ploughing and harrowing has been going on for the last two years. The fertility of the soil has by now been so greatly reduced by exposure to the rays of the sun accelerated, doubtless, by mechanical disturbance, that a crop of green manure sown this season has achieved no more than a stunted growth. Vageler in his 'An Introduction to Tropical Soils' states that "The widely held view of native cultivators in the Dutch East Indies that felling of tree cover for a period of three years, combined with exposure of the soil, is enough to destroy the richest bed of humus is precisely what one would expect from such a procedure. It is unfortunately true that even now unreflecting introduction of European practices in the matter of bare fallow occasions much damage in many tropical regions". It has recently been found in the United States that nitrate and nitrite-producing organisms are rendered inactive or destroyed by exposure to sunlight.

During the present epidemic of malaria in some districts in Ceylon this review would be incomplete without drawing attention to the short section in this book on malaria in which it is stated that recent work by Williamson in Malaya "strongly suggests the possibility of reducing anophelines, especially the dangerous pure-water species, by contamination of breeding places with organic debris".—L. L.

FIVE YEARS OF CACAO RESEARCH 1930-35

IT was mentioned in the Review of the first annual report of the Cacao Research Scheme (which appeared in the June 1933 number of this Journal) that the Scheme was established in the first place for five years, at the end of which period the position would be reviewed. The five years are almost completed, and in anticipation of the review there has appeared in *Tropical Agriculture* (Vol. XII. No. 7. p. 169. *et seq.*) a concise summary of the achievements of the Scheme during that period. Detailed accounts have appeared in Annual Reports, but this summary presents the conclusions that may be drawn from those reports, shortly and simply. A perusal of it indicates two further conclusions—that the men who planned the Scheme worked on very sound lines, and that the extension of its period of activity is essential. It would be a tragedy if the very solid foundation that has been laid during the last five years should be allowed to remain without a superstructure.

Some idea of the breadth of this foundation will be gained when it is stated that the botanical side of the work includes the determination of standards by which future work will be measured, a quantitative and qualitative survey of Trinidad cacaos and a calculation of the range of variation in them, an enquiry into the best means of vegetative propagation, a study of the mechanism of fruit setting and the faults that may develop in it, physiological root studies, statistical examination of yield records and an enquiry into the method of inheritance of pigment in the cacao bean. Most of these foundation stones require to be built on before they are visible to the eye of the layman (or in this case, the planter), and for that reason it is essential that the Scheme should continue. At the same time, 100 trees have been selected for progeny tests as a result of yield figures collected from 1,000 trees over the last 3 years, and there has been evolved a technique of vegetative propagation that gives a high percentage of successes and a comparatively uniform progeny. The collection of data, too, has illustrated to the planter how he can produce an immediate improvement in his crop by the elimination of the poorer trees and their replacement by budded or seedling progenies from selected bearers.

The foundaiton stones on the chemical side are equally firm, and have already fulfilled part of their purpose. For example, it has been determined that the soils of the less fertile cacao areas have an unbalanced nutrient supply and that the limiting factor is usually phosphoric acid; spectacular increases of yield have been obtained by the addition of this fertilising constituent. It has further been determined that leaf analysis will indicate, not only soil composition, but also yield, through its relationship to a balanced nutrient supply. High yield is associated with a high potash content of the leaf relative to nitrogen and phosphate and a

low phospate content of the leaf relative to nitrogen and potash, and optimum values of the ratios between these constituents have been determined. Other investigations have included soil surveys of 178 different places in Trinidad, Tobago, and Grenada, correlations between the features of these soils and the yield of the cacao growing on them which have resulted in definitions of "good" and "bad" cacao soils, the effect of mulching, and the effect of soil deficiencies of a particular nutrient factor upon the character of the vegetation. Some evidence has been obtained of the influence of proper manurial treatment on quality, but this line of enquiry needs to be further and more exhaustively followed. This we are sure will happen during the next five years of the Scheme's useful life.—J. C. Haigh.

A NEW AGRICULTURAL JOURNAL

"The East African Agricultural Journal"—*Edited by the Director of the East African Agricultural Research Station, Amani, published bimonthly.* Price 1*s*. per copy or 5*s*. annually, post free, Government Press, P.O. Box 128, Nairobi.

THE original *Agricultural Journal of the East Africa*, first published in April 1908, was discontinued in July 1914. A new periodical under the title of *The East African Agricultural Journal* has recently appeared in response to a growing demand for a publication which will deal authoritatively with the varied problems which progressive farmers and farmers' associations have to face in East African territories.

This journal is edited by the Director of the East African Agricultural Research Station, Amani, Tanganyika, assisted by an Editorial Board consisting of the Directors of Agriculture of Kenya, Tanganyika, Uganda and Zanzibar. It should be assured of success by reason of its practical value to all agriculturists not only in East Africa but in all countries having similar agricultural problems to the territories mentioned previously.

The first issue July 1935 includes a number of original articles by scientific officers of the Department of Agriculture concerned and is well produced and illustrated. Of particular interest to Ceylon agriculturists are articles on tea cultivation, on kiln-drying of copra, on vegetative propagation of coffee, on cotton breeding and on the production of flue-cured tobacco.

The East African Agricultural Journal is published every other month, January, March, May, July, September and November.

MEETINGS, CONFERENCES, ETC.

COCONUT RESEARCH SCHEME (CEYLON)

BOARD OF MANAGEMENT

Minutes of the twenty-eighth meeting of the Board of Management, Coconut Research Scheme, held (by the courtesy of the Acting Financial Secretary) in the office of the Financial Secretary, New Secretariat, Colombo on June 7, 1935.

Present.—Dr. W. Youngman (in the Chair), Hon'ble Mr. C. H. Collins, C.C.S., Treasury Representative, Hon'ble Mr. F. A. Obeyesekere, M.S.C., Messrs. Graham Panditteseker, J.P., U.P.M., A. W. Warburton-Gray, J.P., U.P.M., J. L. Kotalawala, M.S.C. and Dr. R. Child, Chief Technical Officer, who acted as Secretary. Apologies for absence were received from Mr. Austin Ekanayake and from Mr. L. W. A. de Soysa.

MINUTES

The minutes of the twenty-seventh meeting of the Board of Management held on March 15th 1935, copies of which had been circulated were confirmed and were signed by the Chairman.

BOARD OF MANAGEMENT

The Chairman reported that Mr. L. W. A. de Soysa had become an *ex-officio* member of the Board on succeeding Mr. R. Sri Pathmanathan as Chairman of the Low-Country Products' Association. The thanks of the Board were tendered to Mr. Sri Pathmanathan for his services.

STAFF

The Board formally sanctioned Dr. Child's leave out of Ceylon to date from October 13, 1935. The darft of Dr. Child's new agreement was tabled and the Board agreed that if Dr. Child agreed to its terms the Chairman should make arrangements to have the formal agreement drawn up by the lawyers and signed and sealed on behalf of the Board.

Sick Leave.—The Board instructed the Chief Technical Officer to refer to the Board for special consideration any cases in which members of the staff exceeded their leave allowance owing to attacks of malarial fever.

Appointment of Field Assistant.—The Chief Technical Officer reported that he had received 69 applications for the post of Field Assistant sanctioned by the Board at the previous meeting. The applications had been carefully scrutinised and he was interviewing a limited number of the applicants and the final selection would be reported to the Board at the next meeting.

FINANCE

The statement of receipts and payments for the first quarter ended March 31st, 1935, was approved by the Board.

SUPPLEMENTARY ESTIMATES

J. 1. Repayment of Government Loan.—The Board formally sanctioned a supplementary estimate under this head of Rs. 68,333.33, which with the previous estimate of Rs. 14,000 covered the payment already approved and paid of Rs. 82,333.33 being balance of Government loan Rs. 80,000.00 and accrued interest Rs. 2,333·33.

A. 7. Capital Account—Copra Kiln.—The Chief Technical Officer asked for a supplementary estimate under this head to build a new copra kiln. Mr. Warburton-Gray remarked that he would like to see the bulk of estate crop cured for copra, as he thought more information regarding various influences on out-turn would be obtained. Dr. Child said that nuts had usually been sold to the desiccated coconut millers in accordance with the desire of the Board expressed at the fifteenth meeting held on 5th February, 1932. Since the commencement in 1934 of the Scheme's first large manurial experiment, all the nuts from this experiment were cured and amounted to about 20 per cent. of the total crop. As further experiments were laid down this proportion would increase. Useful figures were usually obtained by the courtesy of the desiccated coconut millers of the desiccated nut out-turn etc. from the nuts sold. Mr. Obeyesekere asked whether it would not be practicable for the Scheme to have a desiccator and thus not to be dependent on the millers for such information; the Chief Technical Officer said he had mentioned in his annual report that it would be necessary soon to consider the provision of small-scale factory plant for experimental purposes. The Board decided that this question should be borne in mind and might be brought up later. With regard to the proposed new copra kiln Mr. Kotalawala asked whether the Scheme should not investigate different forms of driers. The Chief Technical Officer's opinion was that a good Ceylon kiln properly worked was quite satisfactory and under present conditions there was little use in an extended study of other types. Mr. Warburton-Gray agreed. In reply to a further question by Mr. Warburton-Gray, Dr. Child said that it was proposed to have a slightly modified platform (covered with wire netting) to make the new kiln more useful in the curing of the number of small lots of copra from the experimental blocks.

The Board decided to approve a provisional supplementary estimate of Rs. 1,500/-, the Chief Technical Officer to commence the work at once.

ESTATE

In connection with the estate progress reports, Mr. Obeyesekere asked whether the crop and production cost could be shown for three years previously instead of merely the previous year as at present. The Chief Technical Officer said that this could be done. The progress reports for March, April and May were approved.

The Chairman mentioned here that it had occurred to him that the minutes of Board meetings as sent to the Press were often made very barren by the omission of all financial and related matters. The present practice was that authorized by the Board at the first meeting held on April 17, 1929 and amended at the seventh meeting held on September 3, 1930, whereby the minutes are issued to the Press after being circulated and approved by the Board, with any amendments or omission at the discretion of the Chairman. He thought that, for example, details of Estate finance, cost of production, etc., might be of interest to the public. The Chief Technical Officer said that a good deal of this information became ultimately available in the annual reports. The Board left the question as before to the discretion of the Chairman and agreed that the minutes for the Press might be less drastically curtailed.

ELECTRIC PLANT

The Chief Technical Officer referred to a letter from Messrs. Brown & Co., following their inspection of the electrical equipment at Bandirippuwa Estate in January, 1935, in which they recommended the installation of meters in the bungalows. The Chief Technical Officer said that it was very difficult to keep a check on the consumption of electricity without meters; readings in the power house had showed on occasions that the consumption of current from the batteries was too high, and that to ensure a reasonable period of service for the batteries it would be necessary to have more control over individual consumption. A supplementary estimate would not be necessary as there would be sufficient available funds in the vote: Upkeep of Power House. The Board instructed Dr. Child to obtain an estimate of the cost of the work.

OTHER BUSINESS

Destruction of Dead Palms.—Correspondence on this subject was tabled. The matter had been referred by the Hon'ble the Minister for Agriculture and Lands to the Hon'ble the Minister for Home Affairs; the latter had asked that it might be allowed to stand over for the time, as it was undesirable to institute prosecutions under the Plant Pests Ordinance at the present time of depressed conditions in the villages. Mr. Warburton-Gray made the suggestion that workers on the malaria relief schemes might be employed to cut down dead palms Mr. Collins and the Chairman thought this suggestion might be communicated direct to the Government Agents of coconut growing Provinces. Mr. Kotalawala indicated some of the difficulties; no officers had a right to enter land without the permission of the proprietor; he thought the subject could best be undertaken by the officers of the Department of Agriculture using means of propaganda rather than by enforcing the Ordinance. The Chairman said that the Divisional Agricultural Officers had insufficient funds at their disposal to do much; Mr. Warburton-Gray's suggestion that free labour (financed by malaria relief funds) might be placed at their disposal could be considered. The Chairman undertook to make an effort to implement the Board's suggestion concerning the destruction of dead palms, by communicating it to the Government Agents and to the Agricultural Officers.

Training of Students.—Mr. Kotalawala asked the Chief Technical Officer whether there was any provision made for the training of students; he thought it would be very useful, for example, if a proprietor could send a man to study at the Scheme such subjects as manuring. Such a man could learn the latest ideas of cultivation and so on and would be the better qualified for his estate duties. Dr. Child said that the Coconut Research Ordinance, 1928, contemplated that the Scheme should provide for the education of students, such being specially mentioned in section 4 (6) of the Ordinance. Arrangements could be made to carry out a certain amount of such work; the chief difficulty was accommodation. As members knew, the neighbourhood of Bandirippuwa Estate was not an easy one in which to find suitable accommodation; he had already come across that difficulty in appointing members of the staff for whom quarters were not provided. Mr. Obeyesekere asked whether the Board could consider the erection of some sort of hostel at the Scheme's station, which could be used by the Scheme's junior staff and by visiting students. Dr. Child thought it was well worth considering as the advantages of having all the staff accommodated on the estate would compensate for the cost. The Board expressed the opinion that these proposals of Mr. Kotalawala and Mr. Obeyesekere should be gone into at a later meeting.

RUBBER RESEARCH SCHEME (CEYLON)

Minutes of the twenty-seventh meeting of the Board of Management held in the Committee Room of the Ceylon Chamber of Commerce, Colombo, at 10 a.m. on June 27th 1935.

Present.—Dr. W. Youngman, Messrs. I. L. Cameron, L. B. de Mel, J.P., U.P.M., George E. de Silva, M.S.C., C. E. A. Dias, J.P., C. H. Z. Fernando, M.M.C., L. P. Gapp, Col. T. G. Jayewardene, V.D., M.S.C., Mr. J. L. Kotalawala, M.S.C., Hon. Mr. F. A. Obeyesekere, M.S.C., Messrs. C. A. Pereira, B. M. Selwyn, (in the Chair), R. A. Sharrocks, J.P., Col. G. B. Stevens, C.B.E., and Mr. E. W. Whitelaw.

Mr. T. E. H. O'Brien, Director of Research, was also present by invitation.

Apologies for absence were received from the Hon. Mr. C. H. Collins, C.C.S. and the Hon. Mr. E. C. Villiers, M.S.C.

Dr. Youngman said he was suffering from loss of voice and requested some one else to occupy the chair. Mr. Selwyn was voted to the chair.

MINUTES OF THE TWENTY-SIXTH MEETING

Draft minutes which had been circulated to members were confirmed and signed by the Chairman.

DECISIONS BY CIRCULATION OF PAPERS

a. *Leaflet on Sulphur Dusting.*—Reported that leaflet No. 15 entitled "Sulphur dusting for Oidium in 1936" had been approved and issued to persons on the Scheme's publication list.

b. *Visiting Agent.*—Reported that Mr. P. R. May had accepted the post of Visiting Agent for the Board's properties and that the first inspection had been made on June 8th. It was decided to invite Mr. D. T. Angus to act for Mr. May during the latter's absence on home leave.

BUILDINGS AT DARTONFIELD

a. *Future Policy.*—Consideration was given to a recommendation of the experimental Committee that the entire Scheme be transferred to Dartonfield. After full discussion it was unanimously decided to accept the recommendation but that no time limit should be fixed for the transfer. The Committee was asked to give further consideration to future staff requirements and to submit detailed proposals for a botanical laboratory which will be required for the use of the newly-appointed Assistant Botanist.

b. *Bungalows for the Chemist and Botanist.*—The Experimental Committee's recommendations were approved and it was decided to vote Rs. 17,000 each for bungalows for the Assistant Chemist and Assistant Botanist, inclusive of furniture, drainage and internal water and electric light fittings. The Committee was authorized to call for tenders and proceed with the work; also to submit proposals for a water and electric light scheme, making provision for future extension.

The Committee was authorised to make arrangements for temporary accommodation for the Assistant Botanist on a neighbouring estate.

ACCOUNTS

a. Statements of receipts and payments of the Board and of the London Advisory Committee for the quarter ended March 31, 1935 which had been circulated to members as C. P. P. 400 and 410 were adopted.

b. Dartonfield and Nivitigalakele accounts for January, February, March, and April 1935 were tabled.

c. Reported renewal of fixed deposits totalling Rs. 90,000 for 1 year at 2¼ per cent. interest.

d. A list of unserviceable articles removed from the inventory in 1934 was tabled at the request of the Auditor-General.

e. Unexpended balances of capital votes passed in 1934, totalling Rs. 35,996 were re-voted.

STAFF

a. *Re-engagement of Mr. W. I. Pieris.*—The Chairman and Mr. C. H. Collins were authorized to decide on suitable terms and to authenticate the Board's seal on the agreement.

ESTATE COMMITTEE

The following recommendations were adopted:—

a. Provision of fuel storage tank at Dartonfield factory at a cost of Rs. 520.

b. Appointment of assistant engine driver at a salary of Rs. 20 per month.

OIDIUM LEAF DISEASE

The report of the Oidium Committee (appointed by the Board at a meeting held on March 14th, 1935) was considered. After discussion it was decided that the Committee be delegated to discuss the report with the Hon'ble the Minister for Agriculture and Lands and his Executive Committee.

ADVISORY VISITS TO ESTATES

A report from Mr. C. H. Collins was considered and it was decided to issue a circular to persons on the Scheme's publications list and to agency houses asking that requests for advisory visits should be limited as far possible to occasions when problems have arisen which are outside the normal scope of estate routine.

A vote of thanks was passed to the Chamber of Commerce for the use of their Committee room for the meeting.

DEPARTMENTAL NOTES

THE PAINTED BAGRADA BUG (BAGRADA PICTA)

J. C. HUTSON, B.A., PH. D.,

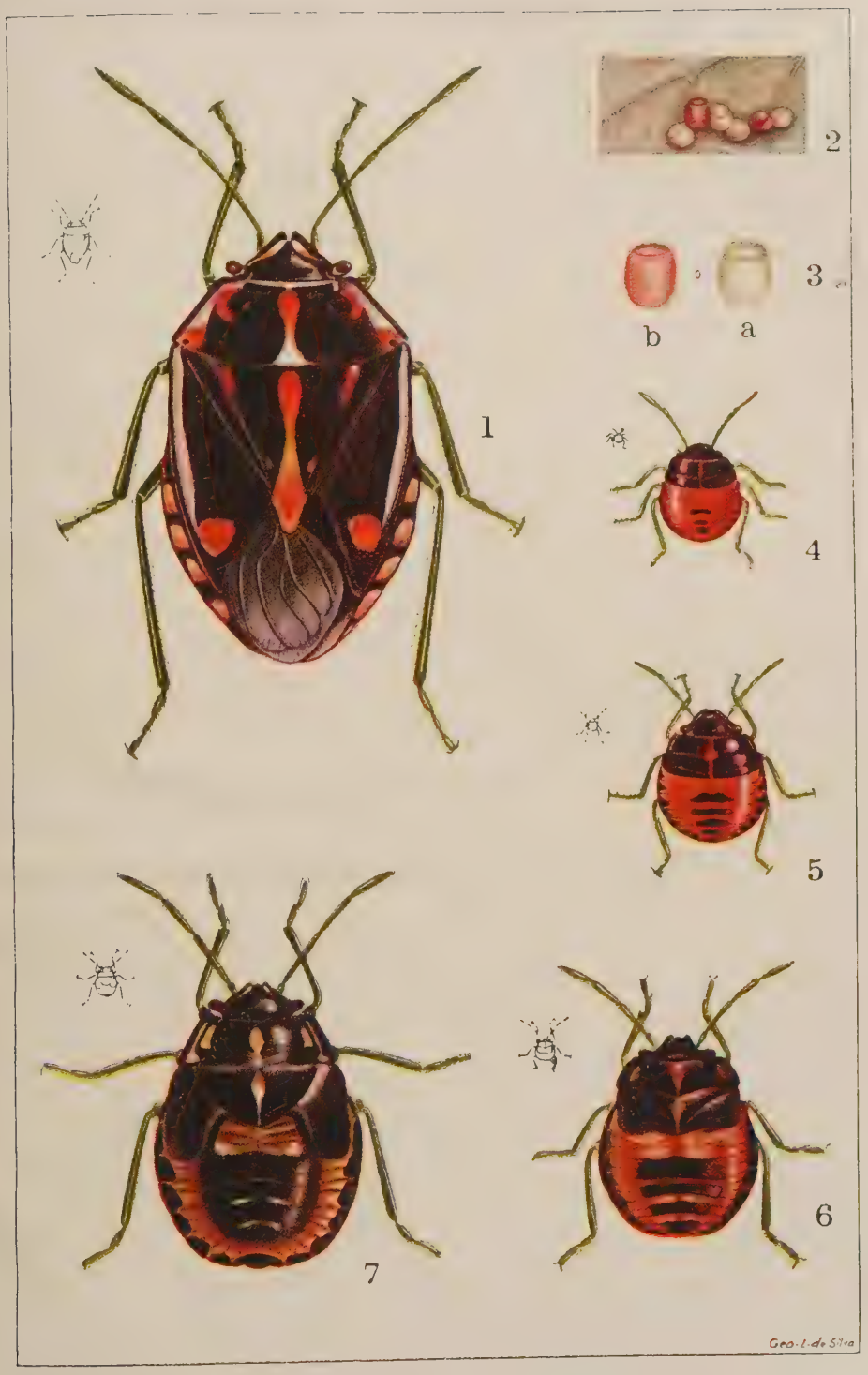
GOVERNMENT ENTOMOLOGIST

NATURE OF DAMAGE

DURING the past year or so there have been numerous requests for advice on the control of the "small black beetle which has been eating holes in the leaves" of cabbage and other cruciferous plants in vegetable plots. Specimens received with these inquiries have shown that the culprits were not beetles but small plant-sucking bugs (*Bagrada picta*) belonging to the family *Pentatomidae*. The holes in the leaves had evidently been made by small caterpillars and not by these bugs, which are incapable of eating the leaves and can only pierce the epidermis and suck up the plant juices from within through their slender beaks. This type of feeding is done by all stages of the bugs which, when abundant, are able to cause serious wilting and sometimes the death of young plants. Later on unless controlled they may spoil the heads of cabbages and cauliflowers grown at higher elevations or ruin a seed crop of mustard in the low-country. On one agricultural station a young crop of mustard was wiped out by these bugs and had to be ploughed in, while on another the attack came on at a later stage and the seed crop was seriously reduced by this pest.

FOOD PLANTS

So far, these bugs have known to feed and breed only on various cultivated plants belonging to the *Cruciferae*, which include cabbage, cauliflower, knol-khol, turnip, radish, mustard, etc. When very numerous in vegetable gardens they have been known to get on to ornamental garden plants in the neighbourhood without, however, doing any noticeable injury. In one instance they were collected in thousands from a young papaw clearing where they were reported to have killed off acres of seedlings, but the drought may have been mainly responsible for the failure of the plants. The possibility of alternate wild host plants has to be considered, but there seems to be no definite evidence on this point so far.



The Painted Bagrada Bug *(Bagrada picta).*

Fig. 1. Adult bug. Fig. 2. Eggs, yellow, freshly laid; pink near hatching, Fig. 3. *a.* freshly laid; *b.* near hatching. Fig. 4 to 7. Bugs of second, third, fourth and fifth instars, respectively.

Fig. 2. enlarged five times, all other figures enlarged ten times.

(Outline figures show natural sizes.)

LIFE HISTORY

In the case of the nine pairs under observation at Peradeniya the life of the females ranged from 20 to 77 days with an average of about 44 days, while the males averaged about 74 days with a range of 44 to 96 days, when kept supplied with food; in every instance the males outlived the females. Mating usually began within a day or two after the two sexes attained the adult stage, but occasionally this was delayed until two or three days later. Mating was observed to take place at frequent intervals during the life of the female. The first eggs were usually laid within a week or so after the female became adult, but in the case of one female the pre-oviposition period was 15 days and in another 21 days. The number of eggs per female ranged from 92 to 217, with an average of 147 for the 9 females. Eggs are usually laid singly at the rate of a few almost every day, but occasionally the interval between each oviposition was longer. Under field conditions the eggs are laid scattered about on the surface of the leaves, leaf-talks or stems. The eggs are pale-yellow when freshly laid (fig. 3a), but turn pinkish before hatching (fig. 3b). During a heavy infestation, single eggs laid at different times may be placed close to each other so as to form small clusters, as shown in figure 2.

The eggs hatch within 5 to 8½ days, the average incubation period being about 6 days. The young bugs develop rapidly and, after passing through five instars (four of which are shown in figures 4 to 7), attain the adult winged stage (fig. 1) in about 3 to 3½ weeks on the average, so that the total life-cycle from egg to adult sometimes occupied less than 4 weeks at Peradeniya; under field conditions in the low-country it may be even shorter, but probably longer at higher elevations. Owing to the comparatively long life of the females and due to the fact that they usually lay their eggs at frequent intervals throughout their lives, one very soon gets, under natural conditions, an enormous number of bugs in all stages of development, this population being made up of at least two or three overlapping generations. These bugs continue to increase at an alarming rate, given a plentiful food supply and other favourable conditions, unless measures are taken to control them.

CONTROL MEASURES

The ability of *Bagrada picta* to breed so rapidly under suitable conditions emphasises the importance of controlling this pest in the early stages of an attack. Usually at such times the bugs escape detection and within a few weeks have multiplied so abundantly that ordinary control measures become almost impracticable. Growers of cabbage and other cruciferous vegetables at higher elevations and of mustard as a field crop in the low-country should be on the look-out for the first appearance of these bugs and should take immediate precautions to check their increase, since there seems to be no effective natural control.

The prompt application of a soap and water spray made by dissolving 1 lb. of hard or soft soap in 6 gallons of water, or 1 oz. in every 3 pints, will help to control the eggs and younger bugs. This mixture can be

applied with an ordinary hand-sprayer and the main object should be to wet the eggs and bugs thoroughly. Hand-picking the younger stages into tins or chatties of water with a film of kerosene is also effective before the insects get too numerous. The adult bugs, on account of their activity and ability to escape in flight, are always difficult to control, and the use of an ordinary paddy-fly hand-net is useful for catching the winged adults, which can be turned out of the net into a kerosene tin half full of water with a little kerosene on the top.

My acknowledgments are due to Mr. T. P. Bonny, former student assistant in entomology, for his work on the life-history and control of this pest.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 31 AUGUST, 1935.

Province, &c.	Disease	No. of Cases up to Date since Jan 1st 1935	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	43	...	43	...	...	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	13	2	...	...	...	13
	Piroplasmosis	...	...	...	...	...	...
Colombo Municipality	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	10	...	9	1	...	...
	Anthrax	2	...	...	2	...	...
	Rabies (Dogs)	18	4	...	...	...	18
	Haemorrhagic Septicaemia	...	...	...	...	...	...
	Black Quarter	...	...	...	...	...	...
	Bovine Tuberculosis	...	...	...	...	...	...
Cattle Quarantine Station	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth dlsease	...	...	...	...	...	...
	Anthrax (Sheep & Goats)	69	3	...	69	...	...
Central	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	1	...	...	...	...	1
	Anthrax	3	...	...	3	...	...
	Black Quarter	18	...	...	18	...	...
	Bovine Tuberculosis	8	...	...	...	...	8
	Rabies (Dogs)	2	...	...	...	...	2
Southern	Rinderpest, Foot-and mouth disease, Anthrax, Rabies (Dogs)	FREE					
Northern	Rinderpest, Foot-and-mouth disease, Anthrax, Black Quarter, Rabies (Dogs)	FREE					
Eastern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	40	...	40	...	...	...
	Anthrax	...	...	...	...	...	...
North-Western	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	105	...	100	5	...	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	18	1	...	2	...	16
	Piroplasmosis	...	...	...	...	...	...
North-Central	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	559	258	423	...	136	...
	Anthrax	...	...	...	...	...	...
Uva	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	85	...	84	1	...	...
	Anthrax	...	...	...	...	...	...
	Bovine Tuberculosis	...	...	...	...	...	...
Sabaragamuwa	Rinderpest	...	...	...	...	...	...
	Foot and mouth disease	...	...	...	...	...	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	2	...	1	1	...	.
	Haemorrhagic Septicaemia	9	...	2	7	...	...
	Rabies (Dogs)	5	...	...	...	...	5

Government Veterinary Department,
Peradeniya, 17th September, 1935

M. WIJAYANAYAKA,
for Government Veterinary Surgeon.

METEOROLOGICAL REPORT AUGUST, 1935.

Station	Temperature				Humidity		Amount of Cloud	Rainfall		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Inches		Inches.
Colombo	84·1	- 0·6	76·0	- 0·3	76	86	7·6	7·87	21	+ 5·23
Puttalam	86·0	0	77·2	- 0·4	74	84	6·5	0·77	5	+ 0·52
Mannar	87·0	- 0·9	78·3	- 0·1	76	84	5·5	0	0	- 0·49
Jaffna	86·0	+ 0·6	78·8	+ 0·3	77	82	5·2	0·23	2	- 0·81
Trincomalee	92·1	+ 0·8	76·5	- 0·2	64	82	7·0	9·70	13	+ 6·19
Batticaloa	89·2	- 1·1	76·0	- 0·2	66	84	6·8	2·91	11	+ 1·11
Hambantota	87·0	+ 0·9	75·6	+ 0·1	74	88	5·4	1·26	11	+ 0·22
Galle	82·2	- 0·3	76·2	+ 0·2	81	86	6·0	6·46	16	+ 1·29
Ratnapura	86·1	- 1·0	73·4	- 0·5	77	95	6·8	14·91	26	+ 4·31
A'pura	92·6	+ 1·5	75·4	+ 0·2	62	88	7·0	0·60	7	- 0·64
Kurunegala	87·1	- 0·4	74·2	- 0·4	69	86	7·4	4·30	17	+ 1·59
Kandy	83·1	+ 0·4	69·6	- 0·4	74	87	7·1	5·70	18	+ 0·23
Badulla	86·4	+ 0·3	63·9	- 0·4	64	94	5·9	4·05	14	+ 1·34
Diyatalawa	77·7	- 0·4	61·7	+ 0·1	62	78	6·5	1·66	9	- 1·38
Hakgala	69·6	- 0·6	57·3	+ 0·1	76	86	6·2	5·29	19	+ 0·26
N'Eliya	66·3	- 0·4	53·6	- 0·5	85	94	7·9	6·81	20	- 0·85

The rainfall for August was appreciably above normal in the south-western low-country, generally below normal in the hills, and generally above in the south and east of Ceylon. In the north-west deficits were rather more numerous than excesses, both however being small. The highest monthly totals were nearly all from or near the Ginigathena Pass, Kenilworth recording 29·12 inches, while totals of 20 inches or over were reported from Watawala, Norton Bridge, Blackwater, Carney, Maliboda, Kellie, Theydon Bois, and Padupola. Very few stations reported no rain at all for the month, but a large number, chiefly in the north-west, on the eastern slopes of the hills, and in the south-eastern corner of the Island, recorded totals under 2 inches.

Only two daily falls of 5 inches or over were recorded, 6·25 at Kenilworth on the 25th-26th and 5·80 at Bandaragama on the 19th-20th.

The usual south-westerly barometric gradients were experienced during the month. Up to the 19th the rainfall in the south-west was fairly light. After that, however, the monsoon rains increased, and some fairly heavy falls were reported until the end of the month. In the dry zone local thunderstorms occasionally gave heavy rain.

Temperature, humidity, and cloud showed generally no marked deviations from average. The barometer was above normal, particularly in the north-west and north. Wind strength at the coast was on the whole about normal, while its direction was mainly S.W. or W.S.W.

H. JAMESON,
Supdt. Observatory.